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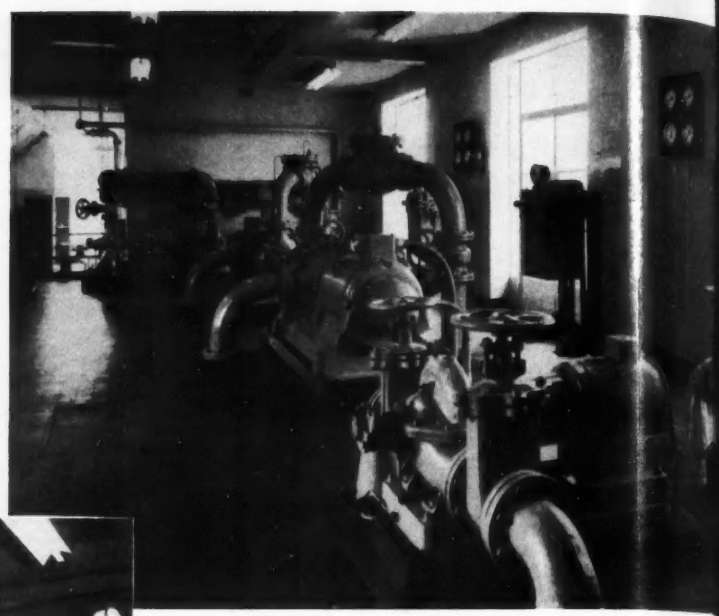

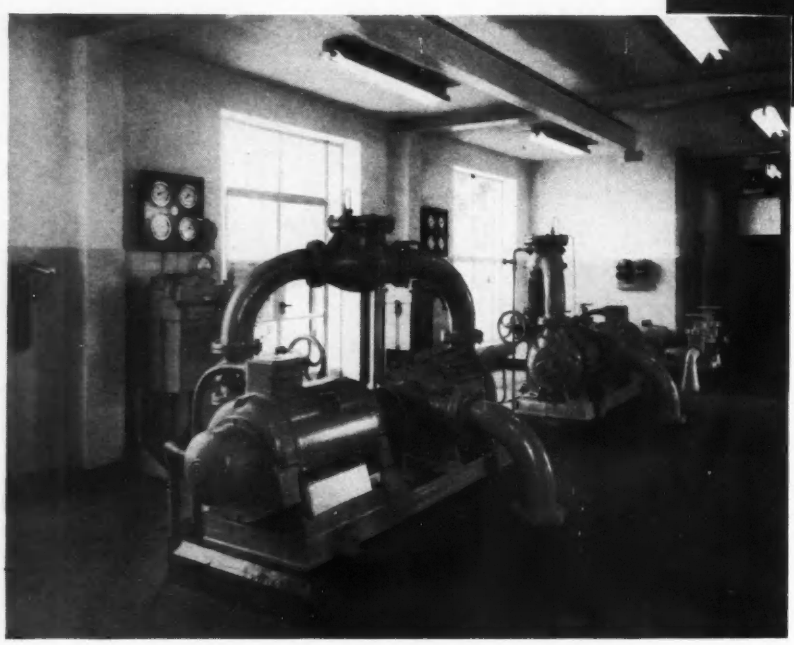

Glenfield Recoil valves and Sluice valves in pumping station of the Shell Brook Wate Supply Scheme of the Mid Sussex Joi Water Board.

Courtesy :— W. H. Ashmole, Esq., M.I.Mun. Clerk and Engineer to the Board.

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THE ENGINEER

VOL. 201 No. 5220 FEBRUARY 10, 1956

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RAILWAY ELECTRIFICATION AT STANDARD FREQUENCY

The recent I.E.E. paper on the potentialities of railway electrification at standard frequency (abstracted on page 194 of this issue) is a timely reminder that the British Transport Commission has not yet decided upon the system to be used for the main line electrification schemes announced in January, 1955. Until a few years ago it would have been reasonably safe to predict that future main line electrification schemes on British Railways would be carried out at 1500V d.c. For this was the main conclusion, based on all the existing evidence, of the report published in 1951 by the British Transport Commission. This conclusion was supported by comparative estimates of four typical schemes with different traffic densities, the estimates being worked out for four different systems, namely, direct current at 750V, 1500V and 3000V, and single phase, 16⅔ c/s, at 20kV. For each scheme the 1500V d.c. system proved to be the most economical. No account was taken of the single-phase, standard-frequency system of electrification which was at the time little more than an interesting curiosity. It is true that since the early 1930s the Hungarian State Railways had successfully operated 118 route miles at 16kV, single phase, 50 c/s, and that a similar system at 20kV had been adopted by the German railways on the 35 route miles of the Hollental line. But little further progress was made for the next fifteen years until French Railways decided to explore the possibilities of the standard frequency system by a trial electrification of the 55-mile section between Aix-les-Bains and La Roche-sur-Foron. So promising were the results of these trials that French Railways adopted standard frequency for electrification of main and branch lines in the north and east. This bold decision was particularly significant in view of the unqualified success attending the existing d.c. electrification at 1500V of 2000 route miles south of Paris. Moreover, the decision is being implemented with commendable energy and it is estimated that the total mileage of electrification by the new system will soon exceed 1500.

What are the advantages of the standard frequency system compared with direct current? As far as the fixed equipment is concerned, the higher voltage possible with standard frequency means a saving in the cost of substations, feeders, contact wires and supports. There seems to be less certainty about locomotive costs. In the report to which we have already referred it was estimated that the annual costs of the standard frequency locomotives would be the higher by about 30 per cent. Experience on French Railways appears to suggest that the difference in locomotive costs is much smaller and that the balance is rather in favour of the standard frequency locomotives. The comparison becomes even less conclusive when account is taken of the costs of structural alterations to provide overhead line clearances, suppression of telecommunication interference, and the cost of bringing power to the railway substations. In a specific study made by the authors of the I.E.E. paper of a project of 300 route miles, with low traffic density, the annual costs of electrification at 1500V d.c. proved to be 28 per cent more than those of standard frequency electrification.

A somewhat different conclusion was reached in a case study quoted by Mr. C. M. Cock during the discussion of the paper. He showed that, for an overseas scheme of 400 route miles with a traffic density of 6,000,000 trailing-ton-miles per annum per mile of single track, electrification was 5 per cent cheaper at standard frequency than at 3000V d.c., but that the costs became almost equal when allowance was made for alterations to telecommunication circuits. In any railway electrification proposals, considerations such as these would determine which is the cheapest system to give a required service. In the case of the main line projects already announced by the British Transport Commission it would be idle to speculate on the choice of system without knowing all the facts. The alternatives, however, are clear and some of their implications are worthy of study. If, for example, one system or the other should prove to be substantially cheaper, the decision would be simple. If, on the other hand, the choice should prove to be more delicately balanced, as may well be the case, we would welcome a decision in favour of standard frequency. For it is a new system with immense potentialities. Already, under the impetus of French enterprise, remarkable technical progress has been made in the short space of five years and there is much more to come.

Its prospects are bright both in Britain and overseas and we believe that British electrical manufacturers should be given the opportunity of contributing to those prospects.

IN DEFENCE OF THE C.E.A.

It is certainly possible, as many a student has discovered, to work so hard and so fast that too little time is allowed for reflection. The Report of the Committee of Inquiry into the Electricity Supply Industry, published last week, conveys to us just that impression. The members of the Committee worked so hard and so fast gathering information and criticism from Sub-Areas, Areas, and Divisions that they have had too little time to digest the information. They have observed, for example, that in several respects Area Boards are critical of the Central Authority. But they seem to have attached too much weight to those criticisms. So much so, indeed, that they even considered the possibility of so reorganising the industry that the Central Authority would be eliminated and that the Area Boards would become wholly autonomous bodies buying electricity from a new "Generation Board." It is even possible that, in reality, the Committee favoured that organisation and only rejected it because it was felt politically impracticable to recommend its adoption. Instead the Report falls back upon a compromise. It is recommended that the Authority be bereft of executive power and that it become a purely "supervisory" body. That seems to us an even more impracticable suggestion. For a supervisory body would be unable to exercise supervisory functions unless it had also the authority to command obedience. Nor, when the functions of the supervisory authority listed by the Committee (see page 192) are examined, do they in fact look very different from those at present exercised by the C.E.A. The situation which the Committee found to exist in the Areas is, in fact, not in reality one that can be altered satisfactorily by any change of the powers of the C.E.A.; it can be altered only by persuading the central authority to exercise its powers differently. It is by no means improbable that too little authority and responsibility is delegated. But the fountain head of responsibility must surely continue to lie with the C.E.A.

Upon another matter, too, we feel that it is necessary to join issue with the Committee. It is recommended in the Report that, in reaching any decision, the C.E.A. should take into account only the economics of the situation leaving out of its calculations any consideration of the national effects. Some of the implications of that recommendation are not easily swallowed. For example, it is very probable that the technical staff has pointed out to the Authority that, with some expansion in numbers, it could undertake the complete design and possibly even the construction by direct labour of power stations, without calling upon independent consultants or outside contractors. The Authority has presumably rejected the proposal, not upon economic grounds, but because the proposition would debar consultants and contractors from gaining experience in this country which could be put to good use in securing contracts abroad. Again, though the Authority owns a fleet of colliers it has presumably on grounds of national benefit refrained from expanding it so far as seriously to affect the interests of coastwise shipping companies. The Committee, of course, recognises that what is economically sound for the electricity industry is not necessarily in the national interest. It wishes, however, the Minister to intervene, rather than the Authority to act when national issues are involved. But surely it should be one of the virtues of a nationalised body that it can exercise restraint out of a realisation of the national interest ? Nor do we find it easy to accept the implication of the Committee's recommendation that it is the duty of any firm or organisation to place its own economic interests above the national interest. Since the war, fortunately, many boards of directors have decided that the firms they control should enter the export market, not because the goods manufactured could not be sold at home, not because higher profits were anticipated, but because it is in the national interest that exports should be expanded. All honour to them!

For the rest the Report starts a number of hares and duly chases them. But most of the hares are old ones and the Committee really has little that is new to discover about them. The long period that elapses between the conception and commissioning of a power station is criticised. But beyond suggesting a greater delegation of power to Divisions to build power stations, or the creation of a Generation Board to take over the work, neither of which it seems to us would substantially alter the cycle time, the Committee has little to recommend. The Committee hankers after tariff schemes that would truly reflect generation costs. So, too, it may be remarked, do Area Boards and the Authority itself. But it is far from simple to devise them. The Committee would have the Boards charge, for making a connection a sum that truly reflects the capital cost of doing so. Thus the question arises as to whether the town dweller should or should not to some extent subsidise the countryman. There is, and has been for years, plenty of room for argument about that point. The Authority is criticised on the financial side on the basis that, according to the Committee's estimates, it did not make a surplus in 1954/55 of £18,750,000 but a loss of £10,000,000. But the Authority keeps its accounts according to the recommendations of the Institute of Chartered Accountants in England and Wales, and it would surely be laying itself open to even sharper criticism if it did not ! It is perhaps true, as the Committee suggests, that more attention could be given to research and more particularly to work study. But it has to be remembered there that rapid progress in the adoption of labour-saving devices may arouse the opposition of trade unions. On one point alone do we feel fully in sympathy with the Committee. If the industry is to recruit and retain men of high ability it should offer salaries comparable with those paid by private firms ; and if the salaries of those serving on the Authority and the Boards act as a bar then they too should be raised. In addition, it possibly needs more recognition that talented men need to carry high responsibility. A material consequence of nationalisation was that at first authority had to be concentrated towards the centre. Now that the overriding authority at the centre has been firmly established it may well be true that responsibility should be more fully delegated to Divisions and Areas.

100 Years Ago

The Engineer

(FEBRUARY 8, 1856)

INSTITUTION OF CIVIL ENGINEERS

"The evenings of January 22nd and 29th were entirely devoted to the discussion of Mr. Robinson's paper 'On the Past and Present Condition of the River Thames.'

"It was explained that the object of the Paper was to direct attention to the present state of the River Thames, in order that by inducing members of the profession to examine it, some method might be devised for preventing the exposure of the mudbanks and shoals at low-water, whereby the atmosphere was tainted and more danger was caused, than by the foulness of the water itself. The author had devised a plan . . . to construct a chain of locks across the river, just above London Bridge, so as to use the piers of the bridge, as portions of the masonry of the piers of the 15 locks, which would afford a lineal water-way of 552 feet, instead of 692 feet, as at present. It was anticipated that the equalisation of the depth of the river would compensate for the width thus reduced.

"This plan would not at all exclude, but rather facilitate, the conveyance of the sewage, by lateral tunnels, parallel with the river, to any distance that might be judged advisable ; but it was considered that no sanitary objections would exist to the raising of the diluted sewage matter, by means of scoop-wheels and small engine power, placed at the mouth of each existing large sewer, and thus discharging it into the river, whence it would run off through the sluices, without the possibility of return. . . . The chief objection hitherto raised against the plan was the reduction of the tidal capacity."

A Seven Day Journal

The Institution of Electrical Engineers

THE Institution of Electrical Engineers has elected Colonel Sir Arthur Stanley Angwin, a past-president of the Institution, to honorary membership "in recognition of his outstanding life's work in the field of telecommunication, both national and international, and of his distinguished services to the Institution." Sir Stanley was educated at Queen Mary College. After a pupilage with Messrs. Yarrow and Co., engineers and shipbuilders, he joined the Post Office Engineering Department in 1906. On his return to the Engineering Department after the war Sir Stanley joined the wireless section, which was then being expanded. He took a major part in the design and construction of the Leafield, Cairo and Rugby radio stations, and in the inauguration of the transatlantic telephone service. He became assistant engineer-in-chief of the Post Office in 1932, deputy engineer-in-chief in 1935, and engineer-in-chief in 1939. During this period many significant technical developments took place, including the introduction and expansion of the short-wave oversea radio telephone services, and the adoption of the coaxial cable system as a normal method of providing trunk line communications. Sir Stanley has had wide experience of international communications and he accompanied Lord Reith on a tour of the Dominions in 1945 to study and report on Commonwealth communications. This tour led to the setting up of the Commonwealth Telecommunications Board, and Sir Stanley was appointed its chairman in 1951, having previously been chairman of Cable and Wireless, Ltd., since his retirement from the Post Office in 1946. In 1953 he was awarded the I.E.E. Faraday Medal. The Institution has also made the thirty-fourth award of the Faraday Medal to Emeritus Professor George William O. Howe, for his pioneering work in the study and analysis of high-frequency oscillations and on the theory of radio propagation, and for his outstanding contributions to engineering education. Professor Howe was educated at the Roan School, Greenwich, and at Armstrong College, Durham University, after which he was apprenticed with Siemens and Co., Woolwich. His services to engineering education began in 1903, when he was appointed a lecturer at Hull Technical College. In 1921 he went to Glasgow University as James Watt Professor of Electrical Engineering, a position he held until his retirement in 1946. Professor Howe took a prominent part in the formation of the Wireless (now Radio and Telecommunication) Section of the Institution in 1919, and in 1921 was elected chairman of the section, an office he held for two years in succession.

D.S.I.R. Appointments

THE Department of Scientific and Industrial Research has announced the appointment of Professor H. W. Melville, F.R.S., as secretary to the Committee of the Privy Council for Scientific and Industrial Research. He will succeed Sir Ben Lockspeiser, F.R.S., who is to retire on March 10th. Professor Melville is at present Mason Professor of Chemistry at the University of Birmingham. Another appointment announced by the D.S.I.R. is that of Professor G. B. B. M. Sutherland, F.R.S., who will take office in September next as director of the National Physical Laboratory at Teddington. Sir Edward Bullard, F.R.S., retired from the directorship at the end of December, and at present Dr. R. L. Smith-Rose is taking charge, as acting director, of the work of the N.P.L. Professor Sutherland is Professor of Physics and director of the Biophysics Centre in the University of Michigan, which appointment he has held since 1949. He is an acknowledged authority on infrared spectrum analysis, and in recent years he has developed special interests in the field of biophysics.

Conditions in Iron Foundries

ONE of the results of the report of the Garrett Committee on iron foundry conditions, which was published in 1947, was the setting up of a joint standing committee to keep under review conditions and developments in the industry affecting the health and welfare of foundry workers. The present chairman of that committee is Mr. T. W. McCullough, H.M. Deputy Chief Inspector of Factories. This week, the committee has published its first report, which reviews its work over the past seven years. The report gives a summary of the conclusions reached in the first comprehensive investigation into the pulmonary risks of iron and steel foundry workers and outlines the activities of employers, trade unions and the Government. It is stated that between October, 1946, and December, 1953, about £3,000,000 was spent by the industry on amenities and improvements in working conditions. Then there are sections devoted to the various kinds of dust determinations, dust observation and photography, dust estimation and dust standards. The various forms of dust control are described, including control by means of local exhaust ventilation on pedestal and other grinders and at the knockout. An analysis is made of iron foundry accidents for 1953, which shows the special incidence of burns, eye accidents, accidents due to handling materials and accidents caused by articles falling. Emphasis is given to the importance of wearing suitable gloves or other hand protection, goggles and safety boots, as a method of bringing about a reduction of these accidents. The two things, the committee says, which are essential to the campaign for accident reduction are a really keen interest and determination on the part of management, and an equally keen interest and the fullest co-operation on the part of workpeople.

Construction of a Concrete Road

THERE has been little experience of the construction of concrete roads in this country in recent years, although design and construction have both shown advances. A recent work in which economic considerations were sacrificed to some extent, to establish a suitable technique for a 10-mile stretch of road, was described recently at the Institution of Civil Engineers in the paper "The Oxton By-Pass Extension," by Mr. R. A. Kidd, county surveyor of Nottingham. The experience gained on this work is considered to be of great value in establishing standards for design and methods of construction for future major road works. The work was undertaken with plants previously used for airfield construction, but adapted for road work, and detailed information on the construction, specifications, testing, and so on, are given in the paper. The principal plant consisted of a mobile twin-drum paver, a spreader of a design developed by the contractor, modified for a 24ft width of slab by the substitution of a spreading screw for the paddle, a 24ft vibrating finisher, and joint cutters. The author pointed out that the contractor was able to work, after a very short time, to a surface irregularity value of well under 50in per mile, and a target of 40in per mile was therefore reasonable, after initial difficulties had been overcome. A device such as the wet-surface profilometer would be of great assistance in reducing surface irregularity, and machinery manufacturers might well assist in that matter. Concreting to a full width of 24ft had not previously been attempted in Britain to the author's knowledge, but did not bring any major problems. Problems associated with joint construction had been the most difficult to solve, and were commented upon in some detail in the paper. Assistance in the design of the works described was given by the Ministry of Transport and Civil Aviation, and the Road Research Laboratory, and the contractor was John Laing and Son, Ltd.

Proposed Memorial to Michael Faraday

THE Mayor of Southwark is convening a meeting, to be held at the Town Hall, Southwark, on Wednesday, March 21st, at 3 p.m., in order to discuss a proposal for a memorial to Michael Faraday. Faraday was born at Newington Butts, in the Borough of Southwark, and as the area is shortly to be redeveloped, the Borough Council feels that there should be some appropriate memorial to so great a scientist. Lord Citrine, chairman of the Central Electricity Authority, is to preside at the forthcoming meeting. The intention is to consider ways and means of raising a fund, to discuss the possible objects of such a fund, and to form an organising committee.

Development Scheme for the Elephant and Castle

THE London County Council has given details of proposals for developing the Elephant and Castle area in South London. The scheme is based on a road improvement, but is comprehensive, involving new buildings for shopping and offices, and several public and municipal buildings. Some of the buildings will, it is hoped, be undertaken by private enterprise ; the entire scheme will have a cost in the region of £10,000,000, and is the Council's largest venture of this kind since the construction of Kingsway. The planning of the site involved exacting problems, for the requirements of a major traffic intersection and of a focal point of local activity generally were somewhat conflicting. However, it is thought that a high standard of civic design will be achieved. The road improvement is based on two roundabouts, with an eight-lane roadway between them. A large roundabout will link five roads, approximately on the site of the present intersection, and the smaller roundabout to the south of it, at Draper Street, will join traffic from Walworth Road to that in Newington Butts before entering the main roundabout. The present road junction at Elephant and Castle handles a peak volume of traffic of about 4000 vehicles an hour, and

it is considered that the new layout will have a capacity at least 75 per cent greater than that figure. With the many other demands of the site, a roundabout layout was considered to be the only practical solution; a "flyover" junction, it was pointed out, would have to deal with seven routes and forty-two traffic streams. The scheme will take about five years to complete.

New Link in the Gold Coast Railway System

AN important new link in the Gold Coast Railway system, which was inaugurated on February 1st, has reduced the travelling distance between the capital city of Accra and Takoradi, the chief port of the country, from 367 miles to under 200 miles. The new single-track railway line is 51 miles long and connects Kotoku junction with Achiasi, the nearest point on the Central Province line. It was built for the Gold Coast Government by Taylor Woodrow (West Africa), Ltd., and the contract, which took two and a half years to complete, was valued at £2,000,000. The consulting engineers to the Gold Coast Government are Rendel, Palmer and Tritton. The line had to be driven through dense forest, bush and swamp country, and the work involved the movement of over 2,250,000 cubic yards of soil, and the clearing of nearly 1000 acres of forest and bush. Seven new bridges with lengths from 30ft to 240ft were built to carry the new line and seven intermediate stations were erected between Achiasi and Kotoku stations, which were converted to junctions. A number of British-built high-speed diesel locomotives are being used for passenger train services on the line. In addition to speeding communications between the east of the country, where the Volta River developments are under construction, and the west, where the £5,000,000 extensions to Takoradi harbour are in their final stages, the new line will enable the rich area through which it passes to be opened up.

Sir Hubert Houldsworth, Bt.

WE regret to have to record the death of Sir Hubert Houldsworth, Bt., Q.C., which occurred suddenly in London on Wednesday of last week, February 1st. Sir Hubert, who was sixty-six, had been chairman of the National Coal Board since 1951, and quite recently it was announced that he would retire in July when his five-year term of office was completed. Sir Hubert was a native of Heckmondwike, Yorkshire and, after graduating at Leeds University, in 1911, with first-class honours in physics, entered the teaching profession, subsequently becoming an assistant lecturer at Leeds University. He gave up teaching, however, to study law, and was called to the Bar in 1926, having a year earlier taken his D.Sc. degree. During the second world war Sir Hubert was fuel and power controller in the north-eastern region, regional controller for the Ministry of Fuel and Power in south and west Yorkshire, and during the last year of the war, controller-general at the Ministry. For the first five years of nationalisation of the coal industry, Sir Hubert served as chairman of the East Midlands Division, and in 1951 he was appointed to succeed Lord Hyndley as chairman of the National Coal Board. In that onerous position, Sir Hubert did not spare himself; throughout his tenure of office he made a noteworthy contribution to the fulfilment of the plans for reorganising, on a satisfactory basis, this country's coal mining industry. Sir Hubert received his knighthood in 1944, and was created a Baronet in the recent New Year Honours.

Liquid Metal Heat Transfer

INSTITUTION OF MECHANICAL ENGINEERS

AT a general meeting of the Institution, arranged in conjunction with the British Nuclear Energy Conference, held at the Institution of Civil Engineers, London, on Friday, January 13th, a paper entitled "The Use of Sodium and of Sodium-Potassium Alloy as a Heat Transfer Medium," by W. B. Hall, B.Sc. (Eng.), and T. I. M. Crofts, A.M.I.Chem.E., associate members, was presented. We reprinted the paper in abstract in our issues of January 20th and 27th. Here we report the discussion.

Mr. D. J. Pepper: I propose to confine my comments to some remarks on storage, design and operational problems. On storage, the authors' test rig involves the use of only modest quantities of liquid metal, which would not give rise to any serious preheating problem, but on a large commercial plant it is necessary to bear in mind that the auxiliary heating load for melting the charge and preheating the circuit would be quite large. Circuit preheating might best be effected by placing the entire sodium pipework in an insulated housing which is itself heated, this having the advantage of bringing the whole circuit to a uniform temperature throughout and avoiding the hot and cold spots which give rise to severe thermal shock. On the subject of materials of construction there is a tendency to go to 18/8 alloy steel if in doubt, which makes for very expensive plumbing. Perhaps we should try to use low alloy carbon steels whenever possible. The authors mention fabrication, and I agree with their remarks. The use of seal-welded flanges, for example, is of doubtful advantage. The experience of my own company is that if a welder knows that his seal weld is going to be tested he makes doubly sure and the seal weld becomes a strength weld. With butt welding the technique is straightforward, but needs care and attention. Gasket joints may be desirable where it is necessary to break into a system frequently. Such joints are best employed with an inert gas seal to remove the pressure differential across the gasket and reduce the tendency for liquid metal to leak out or for air to leak in. It could be connected to the gas space of the system expansion tank.

It would be interesting to know what the valve makers themselves think about the valves. I believe that the design given in the paper originated inside the A.E.A. Liquid metal pumps are very much a specialist field, and in the commercial world good progress has been made with electromagnetic and mechanical pumps, with suitable encouragement and help from the A.E.A. I have one point on level measurement. The authors describe methods which are certainly ingenious and perhaps justified in a laboratory rig. Our experience, however, is that a commercial instrument of the float-operated air relay type is fairly suitable for the continuous tank level measurement of sodium. With regard to instruments generally, it seems to me that the first step in tackling the problem is to go to the instrument specialists and see whether any of their established products are suitable for adaptation to a new field. The authors mention oxide removal. One should take care not to have more cold traps than one has bargained for. Whenever there is a dead leg the temperature must be controlled at above the trap operating temperature.

The authors do not mention cleaning. No system which has ever been made drains completely, and it may be necessary to remove sodium residues where maintenance or inspection have to be undertaken. There are several ways of doing this. Having tried solvent cleaning with anhydrous ammonia in bulk, I am sure that there is a case for using steam cleaning.

The most important item in a sodium heat transfer system is, of course, the heat exchanger. For power production we are concerned with the problem of using hot sodium to generate and probably to superheat steam. To generate steam we can use a sodium/water heat exchanger, or an indirect method whereby we only heat steam with sodium and use some of the steam to evaporate water. Any sodium/water heat exchanger must be 100 per cent proof against cross leakage of the working fluid. The authors mention a leakproof heat exchanger in which the water-carrying tubes and the sodium-carrying tubes were thermally linked by a solid block of aluminium. It is also possible to use copper vanes to link the two sets of tubes. To protect the copper at high temperatures the heat exchanger is encased and there is a small nitrogen pressure inside. We have used a single tube wall, but for a land-based plant it is worth while playing safe.

A very good method of steam generation would be a Loughborough system. The Loughborough principle requires a steam pump, but there are other methods in the same family which do not. The sodium/steam heat exchanger could reasonably be a simple shell and tube type with a single tube wall between the steam and sodium. There is no danger of the accidental mixing of sodium and steam through tube failure, since there is no significant volume change, but the chemical reactions inside the sodium system arising from the entry of steam can be an embarrassment by choking the sodium circuit.

The field of application is a very wide one. For example, apart from reactors there is a possibility of using liquid metals in the reheat steam cycle. There is also little doubt that their use can be extended in chemical process work for higher temperature levels than are feasible with the more common heat transfer fluids. No doubt heat exchanger problems are occupying the minds of many engineers, and it will be most interesting to hear what subsequent speakers have to say on the topic. Finally, it is most encouraging to hear that liquid metals are to be used in the United Kingdom in a reactor. The sooner we can turn from a laboratory scale to a power station scale, the sooner we shall build up sound experience and with it confidence.

Dr. J. M. Kay: I am particularly pleased to know from this paper that the authors have been able to use ordinary materials of construction, mild steel and stainless steel, and that they have been steadfast in their refusal to be led into using unnecessarily exotic materials and techniques. There are three problems in removing heat from a nuclear reactor. There is first of all the problem of the heat flow by conduction inside the fuel elements, getting the heat from the body of the fuel to the surface of the fuel elements. Secondly, there is the problem of heat transfer from the surface to the coolant, and, thirdly, there is the problem of heat removal in the coolant stream itself, the heat capacity of the coolant stream, an aspect which is frequently overlooked. Any

one of these three aspects may fix the practical upper limit of the heat rating of a reactor. Liquid metals effectively reduce the second problem ; they can offer us heat transfer coefficients of 10,000 B.Th.U. per square foot per hour, per degree Fahrenheit and upwards. However, as the authors rightly point out, there is nothing to be gained in increasing heat transfer coefficients indefinitely, if one has, in fact, come up against the limit of heat flow inside the fuel and heat flow through the tube walls. With regard to the heat capacity of the coolant, liquid metals do not show up quite so well. The specific heat of sodium is only about one-third that of water, and I think that that of the sodium-potassium alloy is lower still. With some of the highly rated thermal reactors where liquid metals might be used as coolants, and *a fortiori* with the fast reactor, there is a very real problem in getting the heat away in the coolant stream. A limitation is imposed in the flow area by the geometry of the reactor core. There is a practical upper limit to the velocity of the coolant through the reactor core, and there is a large temperature range from inlet to outlet and perhaps a very large temperature range. The low heat capacity of liquid metals is therefore a point to bear in mind. The ideal reactor coolant would combine high thermal conductivity and high specific heat with high boiling point, but I am afraid that no such coolant exists. In conclusion, I should like to ask the authors what particular industrial applications they can foresee outside the nuclear field. Mention has been made of the possible use of liquid metals for reheating in steam plant. I should like to ask the authors whether, in the course of their experimental work, they have been able to foresee any particular applications in process engineering.

Mr. C. D. Boadle : So far the main emphasis in this country in liquid metal work has been on its application to nuclear energy ; but, as previous speakers have said, it also has an application towards process engineering generally and the provision of heat, particularly at high temperatures, for all sorts of chemical and power engineering possibilities. In this respect the liquid metals as a group offer the prospect of transferring heat at very high temperatures with very low system pressures. The stage can quickly be reached where the limitation on temperature is imposed not by the fluid, but by the structural materials of which the system is made. In this respect most of the systems which have been considered up to now do not really impose any very serious limitations on materials of construction, because temperatures in excess of 500 deg. Cent. have rarely been considered, so that the normal austenitic 18/8 stainless steel is more than adequate for the duty required of it. Generally speaking, working stresses, apart from thermal stresses, in heat exchangers are fairly low. When, however, we come to consider applications to gas turbines, with temperatures of the order of 700 deg. Cent., we at once have to consider exotic materials, high-creep materials, such as the Nimonics and others. There is, however, one exception. As long as we are committed to the use of electromagnetic pumps in these circuits we must use a high-resistivity material for the chamber of the pump, and this compels us to use either austenitic stainless steel or a Nimonic. This in turn provides another difficulty in the way of using some of the cheaper materials for process circuits, where the general duty is rather less arduous than for some of the higher-temperature circuits. If we attempt to use a ferritic type of material for the major part of the circuit, which would be quite practicable, inevitably we should be faced with the problem of joining a stainless steel or Nimonic pump channel to a ferritic material in the rest of the circuit ; and, as high-temperature steam engineers are well aware, this is a problem for which no adequate solution has yet been provided.

For most industrial applications it seems that the additional cost of sodium-potassium alloy as compared with the cost of sodium—the difference is a factor of 5 or 10 in price—is more than outweighed by the added convenience of not having to preheat circuits for use with sodium-potassium alloy. Most industrial applications in any case would use the liquid metal as a heat carrier between two gas streams, or something of that sort, so that we are not hard pressed on the liquid metal side for heat transfer and could accept the inferior qualities of sodium-potassium alloy without any difficulty.

On the subject of cleanliness, it has been an almost universal practice in this country to make circuits to the very highest standard of cleanliness possible, frequently using electrolytically polished surfaces, or certainly chemically-cleaned interior surface on the circuit, and to use the very highest standards of welding and generally to take great pains to exclude oxygen in all forms as far as possible. It is interesting to compare this with American practice. One company, at any rate, which has done a great deal of work in the U.S.A. takes no trouble to clean the inside of the pipes, again using 18/8 austenitic stainless steel. It takes no trouble when welding, except to use argon arc welding throughout, allowing the inside of the weld to oxidise to its heart's content, and it relies entirely on a cold trap to clean up the oxide produced in the circuit. As a result of this in eleven years' running it has had no failures.

Undoubtedly the use of the cold trap is mandatory in all these circuits. It now seems, from the general accumulation of experience, that, provided care is taken to cold trap a circuit properly, there will be no difficulty whatever from corrosion. This is a point which might well be brought home with some emphasis, in that we have here a pair of fluids, sodium and sodium-potassium alloy, which not only have very desirable heat transfer and hydraulic properties, but are essentially non-corrosive liquids so long as fairly simple precautions are adopted to reduce oxide in the system. In addition, although chemically they are very reactive, the general hazard from any mishap is very much less than would be imagined. On all the occasions in this country, when there has been any accidental escape of sodium from a circuit, there has never been a serious fire. The fire-fighting techniques for extinguishing fires are well known. The fires can be extinguished very rapidly indeed, and there is no danger of any vapour explosions, such as exist with oil fuels. When a fire is out it is out completely and stays out.

I have one or two small points in connection with the authors' remarks on pressure measurement. This, of course, is one of the bugbears of these systems at the moment, in that there are no really reliable pressure measuring instruments on the market. Those remote pressure transmitters which are available all suffer rather seriously from temperature effects. They are by no means temperature-independent and have rather dubious mechanical reliability as well. I should like to enter a plea for some rather better instrument for use with liquid metals. This also applies to the question of level measurement, which is in effect the same problem as pressure measurement.

Mr. W. B. Woollen : I should like to take part in the discussion on the standards of construction which have to be set in this work. My general impression is that the standards described in the paper are probably not sufficiently good for reactors, and that the standards there will probably tend to improve slightly on these ; but the standards for other uses of liquid metals will, I feel, decrease. I think that they must do so, because we are now thinking in terms of the use of expensive materials such as 18/8 steel, which put up the cost of construction very much. If we use lower alloy steels whenever possible we shall cut down costs considerably. There must be some divergence, therefore, between the standards for reactors, on the one hand, and for other uses on the other.

One serious disadvantage of sodium, which is not brought out in the paper, is the blocking to which previous speakers have referred. This difficulty probably arises in other chemical engineering fields. The point is that if there is any contamination from the heat exchanger circuits with steam or water getting into the sodium, solid compounds are produced which block up the circuit completely. I do not believe that there is any way of removing them without stripping down a complete circuit. Ammonia cleaning, steam cleaning and so on will not clear blockages, and this is a serious difficulty with a liquid metal circuit. Maintenance can be carried out very simply indeed. It is quite possible to break into circuits. It is possible to break flanges and take components out without doing more than drain the liquid metal out of the circuit. There is no fire or contamination danger whatever, and the slight amount of oxide produced is cleaned up by the cold trap. In the paper the remark is made that sodium leaks seal themselves off. I think that what the authors really mean is that sodium leaks never start, that the leak is blocked up before the sodium starts leaking out. In this country we have had very little experience of faulty welds causing leaks, whereas in the U.S.A. they have had considerably more difficulty. We have a good deal more to learn in this field.

Mr. B. T. Shaw : To most of us, and particularly to those not directly connected with the nuclear field, sodium is something with which we have not had a great deal to do, since our schooldays, and something of which there is a general horror. There is a genuine fear, either a healthy respect for, or a real dislike of, the material. I should like say that in an attempt recently to show a demonstration fire to the London Fire Brigade, it ended in failure and there was not much of a fire to show anybody ; but on the following day, with a rather humid atmosphere, when a very small quantity was blown out of a valve from the end of a line to clear it we had quite a bang. I think, therefore, that the humidity and other conditions are important.

There is most certainly an application for liquid metals in the chemical industry. Here is a heat transfer medium which will operate at temperatures above that of the diatherms and the various patent liquids. The fused salts, which operate in the same range, have the disadvantage of a high melting point. I agree with Mr. Boadle's remark that the sodium-potassium eutectic is probably a good choice in the chemical field. On a large installation, assuming that the authors and others do not produce sufficient results to enable mild steel only to be used, so that stainless steel must be employed, the percentage cost of filling the circuit is very small,

particularly if we require it to be fully instrumented, completely foolproof and safe.

Mr. P. A. Rottenburg: All the work which the authors describe, and all the work which has been done so far in America, as far as I can see, has been done in 18/8 stainless steel, which adds enormously to the cost of the equipment. If the chemical industry is to use liquid metals it must use them in the cheapest possible material, and that, in many cases, will be either mild steel or a low-alloy ferritic steel. I was very pleased to see that in the large tome produced by the American Atomic Energy Commission and the Department of the Navy it is said that several large-scale mild steel circuits are in preparation or have been authorised.

At the moment this process has not got a terrific advantage from the point of view of the chemical industry over the heat transfer salts which Mr. Shaw mentioned, because they can be used in mild steel. They have their disadvantages, but those disadvantages are difficult to present in pounds, shillings and pence. To use 5 per cent chromium steel and heat transfer salts is cheaper than using 18/8 stainless steel and liquid metals.

Dr. L. R. Blake: The authors say that electromagnetic pumps tend to become inefficient when used on liquid metals of low conductivity, such as lead-bismuth alloys. This is true, of course, but some idea should be given of how low the efficiency falls. With a fairly large pump of some 2000 gallons and 50 lb per square inch, efficiencies can be realised with bismuth approaching 40 per cent, and, if efficiency is the goal, it is often possible to raise this further. I agree generally with the authors' figures of 60 to 70 per cent for mechanical pumps and 40 to 50 per cent for electromagnetic pumps, but again I would emphasise that with sodium, where linear induction pumps are so useful, these figures can be raised if a real need is shown. Mr. Boadle's remark that high-resistivity exotic steels are necessary in induction pumps is not entirely true. In the case of a fairly large pump of a total input power of about 500kW only some 70kW are tube wall losses, even when the tube wall is about 0·1in thick, and it is possible to use lower resistivity materials without a great loss in pump performance. Some of the ferritic stainless steels and austenitic stainless steels are magnetic, and that is a more important disadvantage from the point of view of the electromagnetic pump.

Mr. A. B. J. Reeve: I should like to give a few further particulars of the 400-gallons-per-minute linear induction pumps used in the experimental work described in the paper and to summarise some of the more recent work in this field. It will be evident that permissible insulation temperature limits the temperature at which liquid metal can be pumped. In the pumps described the windings were insulated with insulation for which the maximum continuous temperature is 180 deg. Cent. To pump liquid metal at 250 deg. Cent., which was the design temperature in that application, the windings were force cooled through holes in the core, thermal insulation being provided between the cores and the tube to minimise heat loss from the liquid. In nuclear reactor applications, however, it is considered desirable to avoid forced cooling, and much work has been carried out on new forms of insulation which will permit higher operating temperatures. In the absence of forced cooling, the bulk of the stator I^2R loss can be rejected to the liquid metal if the windings are run at a temperature not much in excess of that of the liquid metal.

The authors replied briefly.

Continuous Tar Distillation Plant

A number of continuous tar distillation plants now being installed in this country by Chemical Engineering Wiltons, Ltd., incorporate a pipe-still of new design. In this article some notes are given on the new pipe-still and an installation completed at the Caerphilly works of the National Coal Board.

THE first of a number of continuous tar distillation plants incorporating a new design of pipe-still was recently completed by Chemical Engineering Wiltons, Ltd., of Cheadle Heath, Stockport, at the Caerphilly tar works of the South Western division of the National Coal Board. In the Wilton tar distillation system developed by the firm an approximately constant volume of hot pitch is continuously pumped in a closed circuit through the pipe-still and distillation column. Crude tar, which is usually pre-heated, is fed into the distillation column where it comes into contact with the hot pitch. This tar, at about 120 deg. Cent., is brought into contact with four or five times its volume of pitch heated to 350 deg. Cent. and the volatile oils are distilled off. The pitch, cooled to 280 deg. or 290 deg. Cent., is recirculated through the pipe-still and reheated. The pitch content of the crude tar originally introduced remains in the circulating system of the pipe-still, an equivalent quantity of pitch being withdrawn from the distillation column as product.

It is pointed out by the makers that with this system the crude tar does not come into direct contact with the tubes of the pipe-still, so that the tar is not directly subjected to thermal cracking conditions nor the tubes to damaging chemical or erosive action. As the crude tar does not pass through the pipe-still it is not essential to dehydrate the tar; and, since no separate dehydrator is required, the water vapour containing ammonia passes through the fractionating column condenser which is protected from acidic corrosion. With the recirculating heating system the hydraulic conditions in the pipe-still can be kept constant, while the rate of tar feed to the plant can be varied within wide limits—coking conditions are therefore minimised and thermal conditions in the still are stabilised even at low loads.

The new Wilton pipe-stills are of two types—radiant and convective—and in them the joints and bends in the small bore spun cast iron pipes are readily available for inspection and cleaning whilst the plant is on-load. The general arrangement of a typical radiant pipe-still and its operating circuit can be seen in the drawing (Fig. 1.) Two separate circulating systems are used, and they may be fed by separate pumps, as shown, or by a single pump from which the delivery is divided by suitable control valves. Pitch from the distillation column is pumped through the pipe-still in metered streams, the pressure in each circuit being measured at the inlet. In each circulating stream the pitch first passes up through a convection bank of tubes, counter-current to the flue gases, the two banks of convection tubes being arranged side by side in the chamber at the back of the furnace. After passing through these tubes, the pitch streams are led into the bottom of the banks of tubes in the radiation section of the still. The two banks of radiation tubes are situated on opposite vertical walls in the combustion chamber with two burners between them. The pitch streams pass upwards through the radiation tubes and are led back to the upper part of the distillation

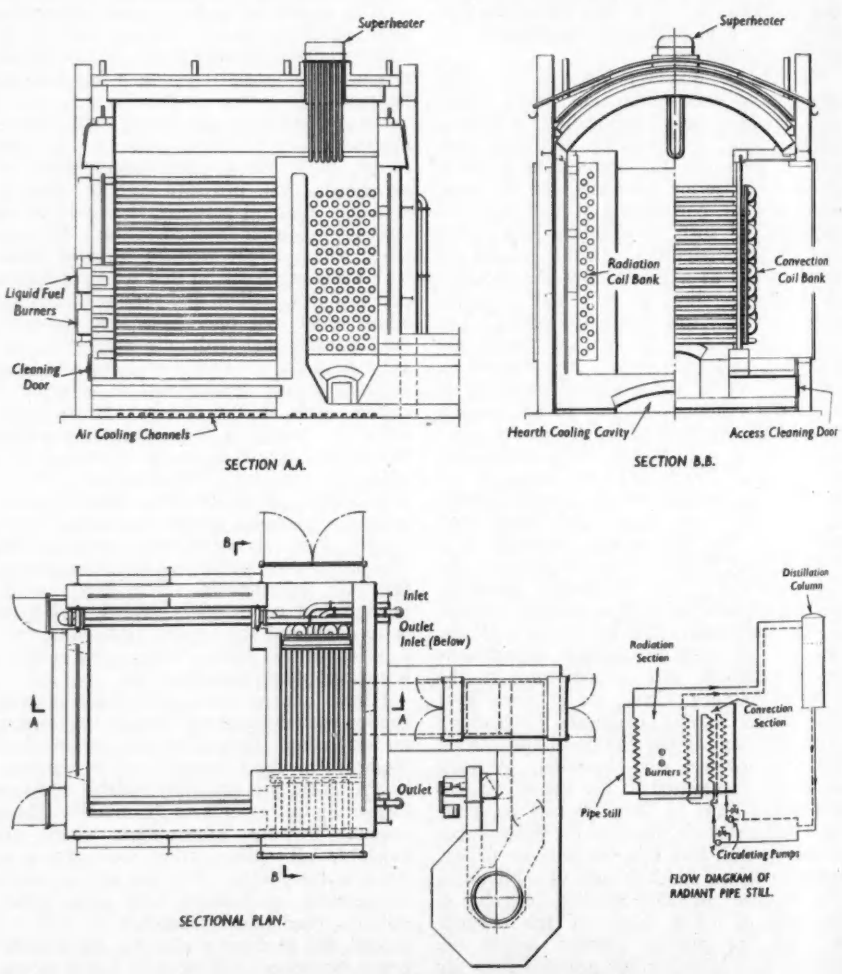


Fig. 1—Arrangement of a radiant pipe-still and its circulation

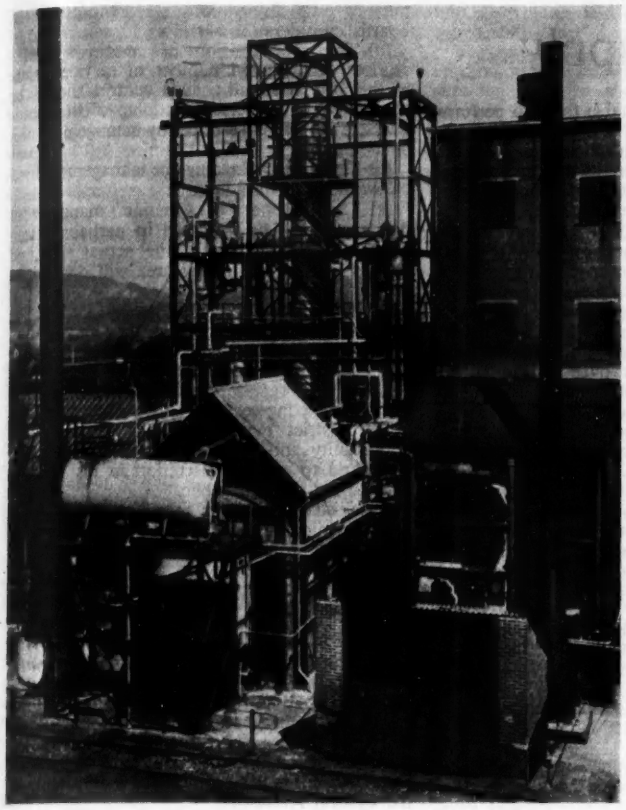


Fig. 2—Tar distillation plant of 150 tons per day at Caerphilly

column. In the convective pipe-still two separate banks of tubes for the pitch streams are placed on opposite sides of a central combustion chamber fitted with a single burner.

The plant installed at Caerphilly is illustrated in Fig. 2, and the flow diagram shown in Fig. 3 is similar in principle, but not in detail, to that plant. A radiant pipe-still is used in the plant detailed in the flow diagram and no tar-dehydrator is installed. Referring to this diagram crude tar from storage tanks is fed through one of two static filters, either of which can be switched out of circuit for cleaning when required. It then passes to two crude tar feed pumps which are automatically controlled to maintain a constant predetermined flow of tar through the system. The tar is then preheated by passing through three heat exchangers : (*a*) a vapour/tar heat exhanger, which takes the latent heat from the vapours leaving the top of the fractionating column ; (*b*) an economiser, which takes heat from the flue gases leaving the pipe-still setting ; and (*c*) a pitch/tar heat exchanger, which takes heat from the pitch leaving the distillation column. Each of these exchangers has by-pass pipes and valves so that it can be drained and serviced while the plant is on load ; all the exchangers are designed so that the tar system can be put under slight pressure it if is desired to suppress vaporisation of the tar before it enters the distillation column.

In the distillation column, there is a series of trays over which the pitch and tar cascade. Hot pitch from the pipe-still enters through the pitch inlet and cascades into the steaming section, where the injection of superheated steam establishes the required pitch hardness and strips the pitch of the higher-boiling volatile oils. These oils pass upwards with the steam to the vapour outlet, pitch entrainment being prevented by the scrubbing of the vapours as they ascend through curtains of cascading pitch. Pitch from the steaming section overflows through a downtake pipe, or alternatively through the central vapour uptake pipe, on to further trays, where it meets the preheated tar entering through the tar inlet. Pitch and tar cascade together in a thin layer over the trays so that the tar is volatilised by the heat in the pitch, the resulting vapours passing upwards through a series of pitch curtains into the steaming section and thence to the vapour outlet. Since all the vapours pass through curtains of the hottest pitch from the pipe-still, they become significantly superheated and carry the superheat into the fractionating column.

The pitch, now partially cooled and containing the heavier oils from the tar, flows to the bottom of the column and passes to a circulating pump, which delivers equal quantities to the two circuits of the pipe-still. In order to keep the circulating pumps fed with liquid, the amount of pitch bled from the system as product is regulated by a valve, operated by a pitch level controller in the bottom section of the distillation column. The partly-cooled circulating pitch is then reheated in the pipe-still. Product pitch bled from the distillation column passes through the pitch/tar heat exchanger, where it is cooled to about 200 deg. Cent.

Volatile tar constituents from the distillation column pass into the fractionating column, which consists of a series of bubble-cap trays. The bottom sections beneath the lowest tray comprise the vapour entry connection and a reservoir for the column residue fraction. The reservoir is equipped with steam pokers so that the residue can, if desired, be stripped before passing out through the seal pot. Vapour from the fractionating column passes through the vapour/tar heat exchanger to the condenser. The condensate passes to the separator, from which the water flows to drain and the oils flow to the reflux tank : the non-condensable gases pass through a foul gas scrubber irrigated with water and are then passed on to be burned in the pipe-still.

The oils in the reflux tank are pumped to the top of the fractionating column, the flow of reflux being controlled automatically from the temperature on the fourth plate of the fractionating column so that the temperature distribution throughout the column is kept stable and constant. The products from the fractionating column (except the residue) pass through meters into their respective storage tanks.

As already mentioned a separate tar dehydrator is not essential in the Wilton system because the crude wet tar does not pass through the pipe-still. The makers state, however, that dehydration is preferably carried out by an extension of the Wilton principle, whereby part of the circulating pitch is mixed with the preheated tar in a separate section of the distillation column.

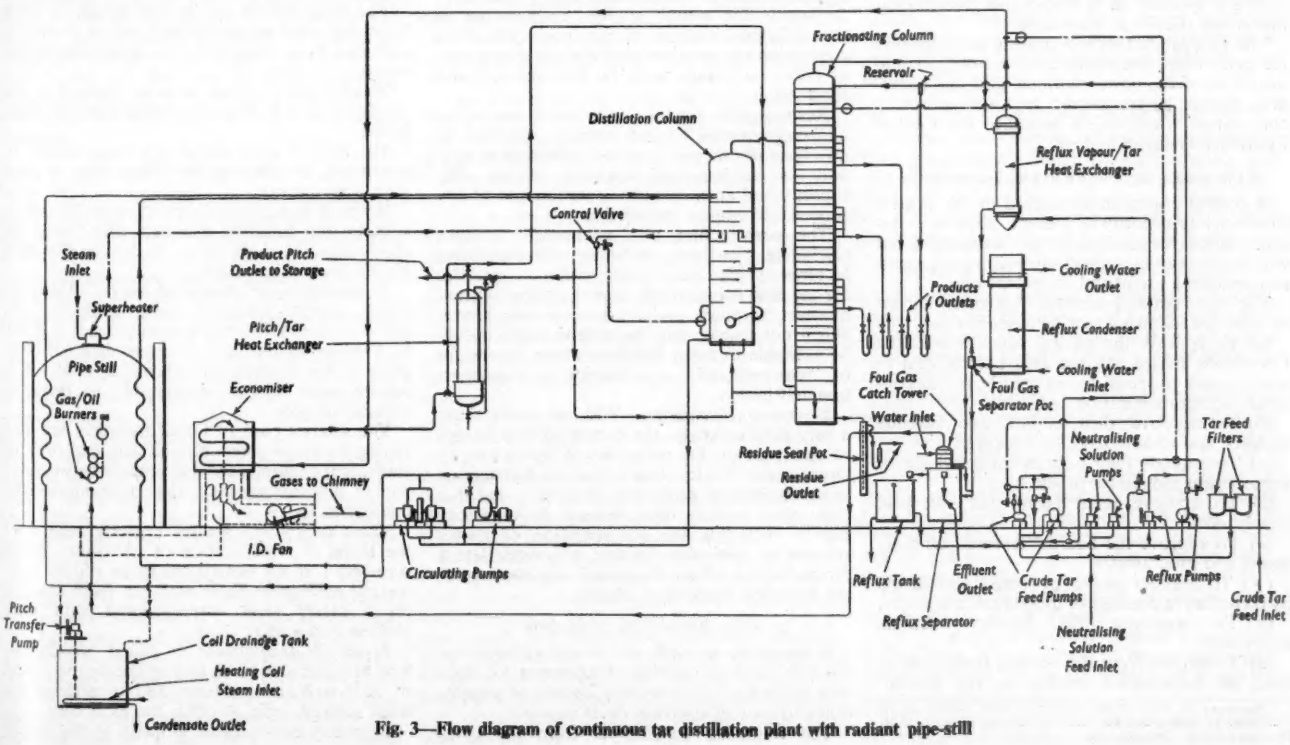


Fig. 3—Flow diagram of continuous tar distillation plant with radiant pipe-still

Report on Electricity Supply*

Aims and Performance of the Industry Under Nationalisation

THE manner in which the amalgamation of the industry was achieved following the enactment of the 1947 Electricity Act reflects credit on all concerned.

The provisions of the Electricity Act require the industry to conduct itself as a commercial concern and to be self-supporting ; they do not preclude it from building up a surplus or suggest that it should be regarded as the custodian of "public money."

The Electricity Act does not require the industry to supply electricity on uncommercial terms to any customer or class of customer nor to conduct itself in such a way that it would have to face higher costs than a private business would face in similar circumstances.

The determination of the national interest is the business of the Government. It is not for the industry to embark in the supposed national interest on any course other than a purely economic course unless so instructed by the Minister subject to his responsibility to Parliament.

The governing factor in the minds of those running the Boards should be that it is their duty to run them as economic concerns and to make them pay.

The degree of public accountability expected of the industry should not be such as to impair its commercial enterprise and efficiency.

Structure of the Industry

The present organisation is in certain respects less well adapted for the industry's future needs than to the initial tasks of amalgamating the industry following its nationalisation.

The industry should continue to be organised on the basic pattern of a series of Area Distribution Boards buying electricity from a Generating Board.

The separation between generation and distribution is sound, but Area Boards should have power to generate for their own requirements subject to approval of the particular scheme, which would be given only in exceptional circumstances.

The present mixture of supervisory and executive functions within the Central Electricity Authority makes it difficult for the Authority to exercise effective and impartial supervision over the industry as a whole and creates confusion and friction in the industry.

The Central Authority's present responsibility for generation, including the construction and operation of the power stations, grid and supergrid, should be transferred to a new statutory corporation which might be called the Central Electricity Generation Board.

Functions of the Central Authority

A central organisation relieved of the Central Electricity Authority's present executive responsibilities for generation and transmission, but with certain clearly defined supervisory functions, can perform a useful and important role.

The reconstituted Central Authority should exercise the following specific functions :—

(*a*) To approve the general plans of both the Generation Board and the area boards, and to approve any proposal by an area board to construct a generating station.

(*b*) To approve their capital and revenue budgets, and to authorise Stock issues.

(*c*) To approve their policies for provision of depreciation and reserve funds.

(*d*) To approve retail tariffs and the bulk supply tariff.

(*e*) To approve the boards' research arrangements and programmes.

(*f*) To consider general or specific complaints by consultative councils or individual consumers.

(*g*) To supervise the labour relations machinery.

(*h*) To require from the boards, from time to time, all information needed by the Central Electricity Authority to enable them to perform the foregoing functions.

The Authority should have statutory powers to issue formal directions to the area and generation boards in regard to development programmes, capital and revenue budgets, depreciation policy and reserve funds, bulk supply and retail tariffs, complaints by consultative councils or individual consumers, research and development and negotiating and advisory machinery ; these powers should be exercisable only after consultation with and approval by the Minister.

The Authority should seek to create for itself a reputation of being at once judicious and stimulating and should see its main duties as keeping the industry on its toes and critically reviewing the boards' policies, programmes and expenditure.

The Authority's headquarters organisation should be small but expert.

The Authority should be required annually to produce and publish reports and statistics, including financial statements, covering the whole industry and an independent and critical review of its finances and its progress.

Headquarters and Divisional Functions under the Generation Board

The Generation Board should retain the following functions at headquarters :—

(*a*) System load control.

(*b*) Planning the general development of power supply.

(*c*) Siting of stations.

(*d*) The design and possibly the construction of stations of advanced design, including nuclear stations.

(*e*) Planning of the super-grid and main transmission.

(*f*) Fuel requirements.

(*g*) Financial policy, including examination and approval of divisional budgets for capital and revenue.

(*h*) Research and development.

(*i*) Staff policy.

Power Station Operation.—For power station operation, the present direct responsibility of station superintendents to the divisional controller is satisfactory, and the Generation Board should need only a small operation section at headquarters to maintain general supervision of the operational side.

Power Station Construction.—The present procedure laid down by the Central Electricity Authority for power station construction is unsatisfactory because of the long cycle from conception to commissioning and the duplication of effort on design work by headquarters and the division.

Responsibility for the design and construction of "conventional" power stations involving no novel features should lie with the division, subject only to headquarters' approval of the site, capacity and amenities of the station and of any proposal to employ consultants.

The construction of "advanced" stations (including nuclear stations), incorporating features which are outside common practice for the time being, might be undertaken by headquarters through mobile construction teams. When not so engaged, the mobile teams should be available to assist divisions where the weight of "conventional" construction is disproportionately heavy.

Divisional Boundaries.—Without undertaking a very detailed study, the committee feel unable to comment on the proposals of the industry's Organisation Review Committee for a reduction in the number of generation divisions ; but it is clear that current developments in electricity supply, including the concentration of power stations in particular regions, will necessitate a further review of the divisional organisation by the proposed Generation Board.

Area Board Organisation

It should be for each area board to determine the best form of internal organisation for their area in the light of its terrain, density of population and state of electrical development.

The following conclusions from the committee's own observations are set out for the boards' consideration :—

(*a*) The concentration of certain specialist services at a limited number of service points in the area is sound ; such centres should be considered as dispersed sections of the headquarters available to service any management unit of the board.

(*b*) There should be only one management level below the Board headquarters.

(*c*) The number of genuine management districts should be increased to perhaps fifteen or twenty in each area ; the actual size and number of districts in any area will depend on the local conditions.

(*d*) These management districts should be identified with the locality they serve and described as undertakings.

(*e*) Below these undertakings and responsible to them, the organisation would consist of outlying engineering sections and service centres.

The district manager should be given the opportunity and the facilities to run his own show and to exercise discretion in his dealings with labour and the public.

The district managers' posts should be used as a training and testing ground for higher managerial positions.

Supply Areas.—The size and boundaries of the twelve existing supply areas are broadly satisfactory.

Membership of the Boards

Composition of the Reconstituted Central Electricity Authority.—The reconstituted Central Electricity Authority should comprise three full-time members, one of whom would be the chairman, and four part-time members ; serving members of the statutory Area and Generation Boards should not be eligible for membership of the Central Authority.

The qualifications required of members of the Authority should not be statutorily defined ; it should be left to the Minister to choose the most suitable men he could find.

Composition of the Proposed Central Electricity Generation Board.—The Central Electricity Generation Board should have a full-time chairman, completely free of special duties, and four to six other members, who should in the main be full time.

Composition of Area Electricity Boards.—The part-time members of an area board have a valuable and important contribution to make and should be chosen with the utmost care ; they should be selected for their individual and collective ability and not as representing any particular interest or section of the community.

The chairman of the Board should be freed from executive responsibilities, which should be exercised by a chief executive appointed by the board.

The Minister should consider appointing the chief executive to be an additional member of the board.

The post of Area Board chairman should be converted, as opportunity offers, into a part-time appointment.

It would be inadvisable for the Area Boards to contain any full-time members other than the chief executive ; the office of deputy chairman should accordingly lapse.

Remuneration of Board Members.—The electricity supply industry must compete with private industry for its top management and will be hobbled in the face of severe external competition for leaders and technical staffs if it cannot offer salaries comparable to those in private industry.

The salaries paid to board members act as a ceiling for those which the industry can offer its staffs, and compress the differentials between the pay of different grades ; this is having serious consequencies.

The Government should urgently reconsider the levels of remuneration of Electricity Board members ; if the boards are to be run as commercial enterprises those who run them must be on a salary level corresponding with their abilities and market value.

Terms of Appointment of Board Members.—The Minister should be free to decide the tenure of all board appointments and to arrange the most suitable term of office for each case.

Relativity with outside industry in the matter

* Summary of conclusions abstracted from *Report of the Committee of Inquiry into the Electricity Supply Industry*, H.M. Stationery Office. Price 6s. 6d.

of salaries should be accompanied by equal risks in the matter of security of employment ; the payment of top salaries should carry with it the expectation of top performance and board members should not be retained in office merely because no obvious deficiencies are apparent.

The Minister should be relieved of the existing statutory obligation to consult the Central Authority on the appointment and re-appointment of members of Area Boards.

Personnel

Recruitment and Promotion of Staff.—The industry should urgently review the conditions which are causing well-qualified men with the calibre of potential leaders to turn away from the electricity supply industry, and should improve the terms of service, including starting salaries and differentials, for graduate trainees.

To ensure a continuing supply of able leaders to fill its top management positions, the industry should have a deliberate system of selective training and posting of able young men, in order that potential leaders may prove their qualities in successive posts and gain the experience which will fit them for higher management.

Redundancy.—An expanding industry is not immune from problems of redundancy, and organisational and technical improvements may be expected to change the manpower needs in different grades from time to time.

The Authority's passive attitude towards redundancy has led to a disinclination of management at all levels to seek out under-employment and to ascertain, by means of work study, operational research and the investigation of restrictive practices, the most effective deployment of manpower.

The electricity supply industry should now adopt a more realistic attitude to this problem and should establish what redeployment is necessary for efficiency ; redundant staffs who cannot be transferred to other work should be released on generous terms to facilitate their absorption into other industries.

Modern Aids to Efficiency

Operational Research and Work Study.—The electricity supply industry has been hesitant to introduce operational research and work study, the value of which is increasingly accepted in other industries ; the new Central Authority should insist on proper operational research and work study being undertaken as a condition of approving budgets.

Incentive Schemes.—The Electricity Boards should study with the trade unions the possibility of formulating schemes of merit pay and incentive payments which would be related to measurable indices and agreed standards of performance, and the revision of the national pay agreements to permit the local agreement and application in each district of appropriate incentives.

Finance

The Central Authority should continue to require each of the area boards and also the generation board to comply individually with the statutory requirement of the Electricity Act that they shall secure that their revenues are not less than sufficient to meet their outgoings properly chargeable to revenue account, taking one year with another.

The existing central reserve fund should be distributed among the generation board and the area boards in accordance with a scheme to be proposed by the Central Authority and approved by the Minister.

A proper apportionment of other assets and liabilities of the Central Authority should be made to the generation board and area boards, as is being done in regard to the South of Scotland under the Electricity Reorganisation (Scotland) Act, 1954.

The administrative expenses of the reconstituted Central Authority should be recovered on some basis approved by the Minister from the generation board and the area boards.

Financial Control.—The Minister must in the last resort rely on the Central Authority to check expenditure by the boards ; the removal of the Authority's present executive responsibilities for generation should make them freer to give unbiased, closer and more critical attention to the supervision of board finances.

The Area Board district managers should be required to prepare reports in the form of a conventional balance sheet and profit and loss account, and should be given the necessary accountancy service for the exercise of full financial responsibility ; they should be encouraged to feel personally responsible for making their individual undertakings pay.

Divisional controllers should produce balance sheets and operating statements on the basis of agreed standards of performance for the Generation Divisions.

Depreciation and Reserve Funds.—The price charged for electricity should be sufficient to recover from consumers the real value of the resources used up each year in serving them.

In presenting the accounts of the industry the surplus should be stated only after charging for depreciation on the above basis.

It is confusing and misleading if the industry's accounts show an apparent surplus of £18,750,000, as in 1954–55, when on the criterion suggested it in fact barely covered necessary charges.

To cushion it against short-run changes in demand and costs and to avoid the need for violent or frequent tariff adjustments, the industry should additionally build up a contingency reserve ; for the time being it would not be unreasonable to set aside for this purpose a sum equivalent to 1 per cent on the capital employed.

During 1954–55 the industry earned some £10,000,000 less than would be required on these criteria before it could be considered to have met its costs, maintained its capacity intact and secured a modest contribution to reserves.

Before resorting to the expedient of raising prices to secure this higher margin of revenue over expenditure, the industry should make a much more vigorous attack upon costs, including the utilisation of capital and manpower.

Financing Methods.—Beyond the levels suggested above, the industry should not build up reserves for financing its own expansion ; to do so would be to impose a compulsory saving on present electricity users for the benefit of future consumers, and could possibly lead to the inefficient use of capital.

The efficient use of capital would be encouraged if the boards had to compete for capital funds on the market without the support of the Treasury guarantee, but this course could only be followed if it were also applied to other nationalised industries.

The Electricity Act should be amended so that each board would go to the market for its own capital requirements and so assume a more direct responsibility for the raising and spending of capital.

The Financing of New Development.—The boards are right to require new consumers to contribute towards the costs of connecting them if it is clear that the revenue to be expected from such consumers is not high enough to cover connection costs in the long run.

The boards should present prospective consumers in this position with a list of the varying methods of contribution which are available.

The costs of connecting rural consumers will normally be higher than the corresponding costs for the urban consumer, but if the rural dweller is to be supplied with electricity at the same price as the townsman he cannot expect at the same time to be given a costly connection free or at a nominal cost.

The industry's present policy of contributing from central reserve funds to any particular board which may, after a five-year period, have incurred uneconomic expenditure on rural development beyond what can be recouped from that Board's own consumers is likely to impair the Boards' commercial responsibility.

In considering the rate at which rural or other development should proceed, each board should apply normal economic and commercial tests, and should aim to stand on their own feet ; if any board find themselves unable to advance rural electrification at the planned rate without financial difficulties, they should re-examine their policy as to the scale of initially unremunerative development and the charges made for connections.

If Parliament decides in the national interest that the boards should pursue policies and incur expenditure which, against normal commercial tests, would be avoided or deferred, the cost should fall on the national exchequer.

Other Matters

The Minister of Fuel and Power might consider extending the scope of his recent survey of steam and power usage to ascertain the surplus capacity of private generating plant and the times when it might be available to produce additional electricity for the public supply system.

The electricity boards should publish tariffs setting out the terms on which they are prepared to buy privately generated power.

Area boards should be free to arrange and negotiate supplies from private generation without having to secure the approval of the Generation Board for their purchases.

Consideration should be given by the Minister and the boards to establishing machinery to ensure that the possibilities of operating private plant in parallel with the grid are appreciated before industrialists decide on the type and size of plant they install.

The electricity boards should seek the best and cheapest plant, taking maintenance and servicing into account, irrespective of origin. They should not circumscribe their own commercial freedom to buy in the most advantageous market by assuming limitations of the national interest which have not been directly determined by the Minister.

The new Central Authority should be concerned only to ensure that the labour relations machinery is working well ; the operation of the machinery, in concert with the trade unions, at both national and regional level should be the responsibility of the Generation Board and the area boards.

Research and Development

The industry should undertake a greater research and development effort and there should be the widest appreciation of the contribution that science can make.

Research and development on the generation side of the industry should be brought together under the full-time member of the Generation Board responsible for research and development, who should be supported by a research staff of high quality.

The area boards should extend their research activities individually, on a co-operative basis with other area boards, and by association where appropriate with the Generation Board.

The utilisation research facilities of the industry should be strengthened and more resources devoted to the urgent ascertainment of the facts required for a valid relationship between costs and tariff charges.

Nuclear Power Programme

The Nuclear Power Branch which the Authority have established should be strengthened and become responsible for the construction, operation and development of nuclear stations ; its head should be of the status of a deputy chief engineer of the proposed Generation Board.

Powers and Duties of the Minister

The ultimate control of a nationalised industry must be in the hands of a Minister responsible to Parliament ; the Minister's powers of giving directions to the Central Authority must therefore be retained.

The most important task falling to the Minister is the appointment of the members of the Central Authority and the individual boards ; the other principal duties of the Minister are :

(*a*) To satisfy himself through the reports of the Central Authority and the individual boards that the industry is being run efficiently on a commercial basis or, to the extent that it is not run on this basis, in accordance with the directions issued by him.

(*b*) To authorise the amount of capital to be raised and the terms of issue.

(*c*) To give the industry precise instructions if and when it is required to act in some way different from what would be dictated by purely economic considerations.

(*d*) To decide whether or not to give consent to the issue of directions by the Central Authority.

Potentialities of Railway Electrification at Standard Frequency

By E. L. E. WHEATCROFT, M.A., M.I.Mech.E., M.I.E.E., and H. H. C. BARTON, B.A., M.I.Mech.E., M.I.E.E.*

No. II—(*Concluded from page 164, February 3rd*)

In a paper presented at the Institution of Electrical Engineers in London on February 2nd the authors discussed the technical and economic aspects of railway electrification with alternating current at standard frequency. Accepting d.c. electrification as a satisfactory method for suburban railways, the authors suggest that, for the new main line projects in Great Britain the 50 c/s system is likely to be cheaper than others and may be installed without technical difficulty. Abstracts from the paper are given here.

Power Supply and Connections

With a low-frequency a.c. system the substations, which, as mentioned previously, are few in number, comprise three-phase/one-phase motor generator sets, and the line conductors are supplied at one phase throughout the whole system. They may therefore be continuous with sectioning points for maintenance purposes only. In this case, the current taken from the three-phase supply system is balanced between the phases. With a 50 c/s system the substations comprise only static transformers, and there is an inherent difficulty in balancing the three phases of the current taken from the supply system. A method adopted in the French electrifications is to make each intermediate substation comprise a three-phase/two-phase Scott-connected transformer, the line equipment being sectioned at the substation and one direction supplied by each of the two secondary windings. If the currents drawn in the two directions happen to be equal, the three-phase current is then balanced. With sections carrying comparatively dense traffic the Scott connection may be used with advantage because in these cases both halves are likely to be well loaded and approximate balance will be obtained on the three-phase side. On light traffic sections, while the Scott connection is still an advantage, it may not be justified if the railway load is very small compared with the industrial load.

An alternative method is to sectionalise the overhead line equipment into three, six or nine "equal" parts (equal in terms of average loading), which can be supplied from the three phases. These are then balanced overall on those occasions when the loads are, in fact, equal. Fig. 1 shows such an arrangement for supplying three sections by "double-ended feed" from four substations. By this arrangement, security of supply is economically obtained with a spare single-phase transformer at each of the substations, with arrangements in the intermediate ones for these spare transformers to be connected to replace whichever phase transformer is out of service. It will be seen that the Scott connection has been replaced by the "open V" connection. The disadvantage of this method is, of course, that the supply to any one substation is never balanced. [The effective overall balance was illustrated by a diagram based on a light-traffic-density project study. This showed the positive and negative phase-sequence components calculated from the ½ min demands drawn by all the starting and running trains on the three sections over one hour, as deduced from the train diagram. The negative-phase-sequence component had a number of high peaks, but on the average it was only about 30 per cent of the positive component.]

Experience in France and the Belgian Congo of working trains through line equipment "dead sections" separating the phases has been satisfactory. Switches are provided to energise a "dead section" in an emergency, and these are suitably interlocked in order to ensure correct operation.

Harmonics and Power Factor

The belief has already been expressed that the rectifier locomotive will prove the most suitable for a.c. electrifications. The waveform of the current drawn from the overhead line, and hence that from the supply, will therefore contain serious harmonics. This fact must be added to the other factors already mentioned (i.e. rapidly varying load and phase unbalance), which have to be met by the supply authority. The harmonics to be expected are of the following order :—

	Per cent
Third harmonic	20–28
Fifth harmonic	10–15
Seventh harmonic	5–9
Ninth harmonic	3–7
Eleventh harmonic	2–4
Thirteenth harmonic	2–3

The higher figures apply when there is heavy smoothing in the d.c. circuit. At one time it was thought necessary to incorporate heavy smoothing on the d.c. side in series with the traction motors, on the view that motor commutation would suffer from an undulating current. Chiefly as a result of American experience it is now considered that, at the most, 20 to 30 per cent smoothing of the undulations is sufficient, and therefore the waveform distortion on the a.c. side may be somewhat ameliorated.

Because of the peaky nature of its demand, any traction load is tolerable to a supply system only if it is rather small compared with other loads, or what comes to the same thing, if it is supplied through feeders of low impedance. If the network is "strong" enough to supply the "peaky" loads which are inherent in traction (whether electrified on an a.c. or a d.c. system) it is generally strong enough to tolerate the phase unbalance and the harmonics. In most caes the railway load forms a small part of the total load and does not tend to expand at the same rate. Thus it is unlikely that the use of single-phase rectifiers on rolling stock will cause any additional embarrassment.

The power factor of rectifier locomotives has been variously given[1, 2, 3] at figures between 0·80 and 0·92. The power factor of the supply to the traction substations may therefore be taken as being generally in the region of 0·70–0·80.

Line Equipment

On d.c. electrifications, with few exceptions, the maximum line voltage in use at present is 3kV. This requires conductors to be generally in excess of 0·5in equivalent copper section, having regard to the combined effect that conductivity, substation spacing and the number of line paralleling points have on voltage drop. Since part of the line work subjected to the greatest wear is the contact wire, it is desirable to provide as large a size for this as can conveniently be installed and maintained. A size frequently used by British engineers is 0·3 square inch cross-sectional area of copper or copper alloy. This contact wire can be used on most d.c. projects, the remaining conductivity required being made up in the catenary or catenary and auxiliary catenary.

On a.c. electrifications where a high line voltage is practicable, considerations of voltage drop permit conductors of smaller copper section to be used. However, considerations of wear, corrosion, maintenance and useful life generally limit the minimum size of contact wire which it is advisable to use, 0·166 square inch (107 square millimetres) being considered a satisfactory compromise. On some early a.c. railway electrifications a smaller contact wire was used originally, but 0·166 square inch is being adopted for renewals. The minimum size of catenary necessary to support this smaller contact wire is again governed mainly by mechanical considerations, and consequently there is some freedom of choice of the material of which it is made. The weight of copper or copper-alloy conductors for a.c. systems may therefore be of the order of one-third or less of those used for d.c. systems, which results in an almost directly proportional saving in conductor costs. Additional savings are also possible because lighter structures and cheaper foundations may be used for support. Indeed, it is possible, even on double track, to adopt single cantilever construction, which is cheaper than portal construction for these light loadings. When climatic and other conditions permit steel to be used for the catenary, the costs may be lowered still further because the conductivity margin may permit this.

Fig. 2, which is based on main line project studies, illustrates the approximate relationship between line-work-component costs for five different conductor areas, and it shows that an a.c. system is appreciably cheaper than a d.c. one. In all these comparisons broad-flanged steel beam structures were used to support copper catenary and cadmium-copper contact wire without automatic tensioning. The cost of track bonding was included (under "conductors") in all cases except that of the 0·24 square inch equipment, where it is unlikely that it would be necessary. There is little difference between the cost of line work for high-voltage a.c. projects operating at between 15kV and 25kV, although the fittings may be a little more expensive as the voltage is increased because more insulation is necessary. At still higher voltages the weight of the additional insulation would influence structure and foundation costs.

The use of single cantilever construction, which is economically possible on a.c. projects, provides independent support and mechanically

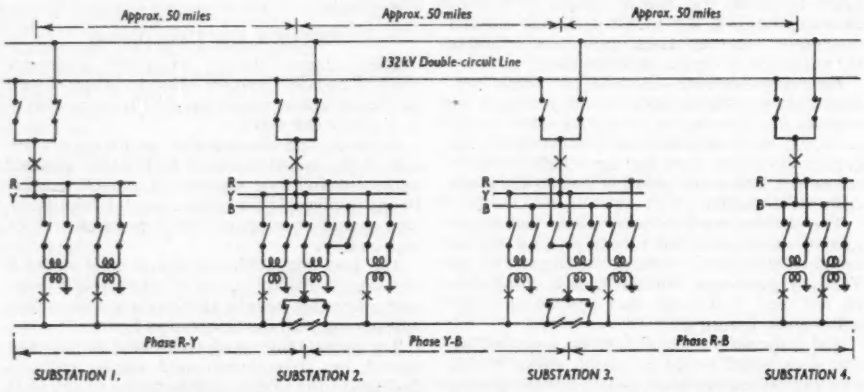
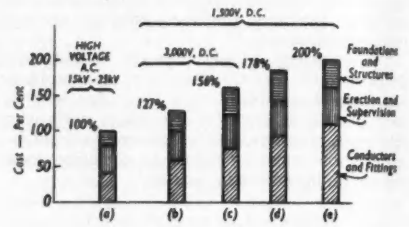


Fig. 1—The "double-end-feed" arrangement for supplying the three sections of line from four substations



	Total actual cross-sectional area	Total equivalent copper section	Catenary	Auxiliary catenary	Contact wire
			Hard-drawn copper	Hard-drawn copper	Cadmium copper
	in²	in²	in (dia.)	in (dia.)	in²
(a)	0·24	0·21	7/0·116	—	0·166
(b)	0·50	0·45	19/0·116	—	0·30
(c)	0·69	0·63	37/0·101	19/0·080	0·30
(d)	0·87	0·81	37/0·116	19/0·109	0·30
(e)	1·07	1·00	37/0·136	19/0·124	0·30

These costs are based on single track construction and a price of copper, £285 per ton.

Fig. 2—Relationship between component costs for different conductor cross sections

* Messrs Merz and McLellan.

independent registration of the conductors. This facilitates maintenance by involving less interference with traffic, it provides drivers with a better view of signals and renders the installation less vulnerable to extensive damage after derailment. The lighter loading permits a wider choice of structure materials, e.g. indigenous timber and prestressed concrete, because the requirements fall within a more common production range. An example of this occurred on a recent oversea investigation when it was found that a local prestressed concrete manufacturer possessed ready facilities for meeting structure specifications for a 25kV system, but not for a d.c. one.

Under favourable earth-conductivity conditions, track bonding will be unnecessary with high-voltage systems, or, at the most, much lighter bonding will suffice. Also, the provision of an independent earth conductor is not so necessary in order to parallel the track on single-line sections. Electrolytic difficulties will not arise.

With a high-voltage a.c. system, annual maintenance expenditure tends to be less because the equipment is lighter ; examples of this occur in structure painting and bond renewing. Finally, the ease with which an a.c. traction supply may be tapped with pole top transformers, thereby enabling undeveloped districts to be "opened up" with a limited electricity supply, may be important. Particularly is this the case if minor power supplies are required along the route for station lighting, signalling and telephone repeaters.

Structural Alterations for Line Work Clearances

Views vary regarding the minimum distances to allow between live equipment and earthed structures for different voltages. High standards are often adopted or proposed where they can be easily obtained. Table III gives published figures for 20kV to 25kV projects. The figures allow for rolling stock movement, i.e. lurching, spring movement, wear, &c., and for the effect of this on the pantograph "moving outline." These figures therefore include the clearances required

Table III—*Line Work Clearances for 50 c/s Projects*

	Mm	In
Belgian Congo—25kV :		
Loading gauge, contact wire at maximum temperature, minimum	290	11·42
Loading gauge, contact wire at maximum temperature, desirable	400	15·75
France :		
Savoy routes, originally 20kV, but later raised to 23/25kV :		
Loading gauge, contact wire, minimum	300	11·82
Loading gauge, contact wire, desirable...	370	14·58
Tunnel, catenary, minimum	400	15·75
Tunnel, catenary, desirable	500	19·70
Tunnel, pantograph horns, minimum ...	220	8·65
Tunnel, pantograph horns, desirable ...	325	12·80
Valenciennes–Thionville routes, 25kV :		
(i) Obstructions extending for some distance :		
(*a*) Mixed steam and electric operation :		
Line conductors to earth (vertical), minimum	370	14·58
Line conductors to earth (horizontal), minimum	370	14·58
(*b*) Electric operation only :		
Line conductors to earth (vertical), minimum	320	12·61
Line conductors to earth (horizontal), minimum	320	12·61
(ii) Obstructions extending for a short distance :		
(*a*) Mixed steam and electric operation :		
Line conductors to earth (vertical), minimum	270	10·64
Line conductors to earth (horizontal), minimum	220	8·65
(*b*) Electric operation only :		
Line conductors to earth (vertical), minimum	220	8·65
Line conductors to earth (horizontal), minimum	170	6·70

for purely electrical reasons plus the effect of whatever margin it has been considered prudent to permit between the load gauge profile and the maximum fixed structure gauge ; in short, the figures include a contingency allowance.

Minimum electrical clearances between live line work and infringing structures will be the same as those adopted for the live portions of the rolling stock. Settling the economical vertical clearances is difficult because of the difficulty in predicting wire lift under the combined effect of equipment tensions and pantograph passages. The horizontal plane clearances will in all cases be governed by the limits set by the pantograph horns. Scope therefore exists for compromise between pantograph width and track structure intervals, which govern the displacement of the line work under influence of cross winds. Consideration of these factors may become important economically if many infringements exist.

The electrical clearances will depend first upon the nominal voltage and the transient values assumed ; secondly, upon atmospheric and climatic conditions, which are affected by such practical factors as the number of steam locomotive passages and the tendency for air pollution in tunnels. Experience has shown that extreme transients, such as those arising from lightning, may be dissipated by means of horn gaps located on track structures at suitable intervals in vulnerable areas or by electrolytic cell or capacitor types of arrester, and that the effects of minor transients, traction surges, &c., are usually displayed at dirty insulators. The authors can only suggest on present experience that the figures for clearances need not exceed those shown in Table III, which have given satisfactory service, and that where special difficulty from sparkover is envisaged, experiments should be carried out. It is understood from French railway engineers that, as a result of recent experience and experiment, smaller clearances than those shown on Table III would be considered adequate for future construction. No figures have, however, been quoted.

It is impossible to generalise on costs, because route topography varies so widely. Examples of this were recently disclosed on two oversea main line studies, neither of which traversed what are generally described as built-up areas. On these projects the estimates varied from as little as £35 per route-mile in the easier case to £5300 per route-mile in the more difficult one, which included tunnels. These estimates were for a 10in clearance to live line work and the pantograph in both planes. It was, however, significant that the cost would be reduced by only about £1000 per route-mile in the more expensive case if the figure of 10in were reduced to 6in, while the cost in the cheaper case would be unaffected by this change.

Consideration should always be given to alleviating action in order to meet special conditions. This may involve the protection of difficult sections with surge-dissipating equipment, the consideration of insulator design to meet special circumstances and the treatment of short tight spots by catenary diversion or other special arrangement.

Telecommunication Interference

Open wire telecommunication circuits which are parallel to and near a.c. track conductors are liable to interference by electrostatic and electromagnetic induction. These induced voltages may exceed the breakdown values normally associated with telephone equipment and even be sufficiently high to become dangerous to life. These circuits cannot therefore be permitted to follow the same route as standard frequency electric railway systems if parallelism is excessive. Apart from the danger aspect, the noise level induced in telephone circuits will be high, in spite of frequent transpositions, on account of the difficulty of achieving and maintaining the degree of line balance on open lines which is necessary to eliminate it. Tests made on the 50 c/s electrified section between Mézières-Charleville and Valenciennes in N.E. France, where open line communication circuits were specially retained for this purpose, revealed that induced voltages could exceed 1kV when the separation distance from the traction conductors was some 10m over a parallel distance of 5km. Although this value fell rapidly to within safety limits as the spacing was increased, the noise nuisance remained even when the communication circuits were moved as far as 300m from the traction conductors.

Harmonic interference injected into the traction conductors and supply network from rectifier rolling stock can also cause noise in telecommunication circuits, and this interference may occur at appreciable distances from the railway if open telephone lines parallel the distribution network feeding the traction system. Standard frequency electrifications may be more troublesome in this respect than lower frequency ones because of the higher fundamental.

While the interference problem is generally greater with a.c. than with d.c. traction systems, particularly from the danger aspect, d.c. systems are not exempt from this. Even rotary convertor ripple voltage was disturbing in spite of attempts to counter it with filters or by coupling armatures to neutralise the pulses. Perhaps interference has become more of a problem in recent years as a result of improvements to telephone channels and equipment, which are now so good that previously accepted standards are hardly tolerable, even on railway circuits.

Of the two methods of countering interference, namely, moving the open lines and transferring the circuits to screened cables, the former course is not always practicable. Indeed, bush country may make it quite impracticable or far too costly, having regard to maintenance difficulties and the absence of any return in the form of betterment or progress. If railway "omnibus" telephone circuits are cabled, the pulse-selective ringing feature may have to be converted to tone frequency coding in order to avoid interference with other circuits within the cable. Provision may also have to be made to loop cabled "omnibus" circuits into trackside connection boxes spaced at mile intervals or less, so that the telephone facilities previously provided by open pole lines are preserved. More repeaters will usually be necessary for cabled circuits, and power supplies will be required for these.

The whole question of telecommunication interference must be considered in line with the development and betterment plans proposed by the railway departments and the Post Office if the latter's circuits are affected. Not infrequently it is found that both authorities have betterment plans in view, and cabling will merely accelerate these plans. Where this is so, part-payment arrangements become acceptable ; indeed, on one recent project it was found that by the time the electrification work could be completed most of the telephone interference problem on trunk circuits would have disappeared as a result of the abandonment of open lines for re-routed coaxial cable channels and microwave radio links.

Significant amounts for cabling need not therefore always be included in electrification estimates ; nor should the cost of this work be advanced as a deterrent to electrification.

Signalling

Manual signalling systems will require very little modification for any system of electrification. More resighting of semaphore signals will usually be necessary with d.c. traction systems than with a.c. systems, because the heavier d.c. structures and line work are more liable to obstruct drivers' vision. On the other hand, with a.c. systems, greater precautions may have to be taken to earth frame and track interlockings, and metallic returns must be provided for block-and-token instrument circuits. These circuits may, however, be included within a screened communication cable.

Most electrifications require the running rails as conductors and, where track circuits are in use or proposed, discrimination must be assured between the signalling currents and the traction currents. This may be obtained on both a.c. and d.c. traction systems with most forms of coded track circuit, but it is likely that steady-energy alternatives would be used for new work instead of coded track circuit except where cab signalling is required.

When steady-energy track circuits are used on d.c. electrifications they must be fed with alternating current, and where both rails are required as traction conductors double-rail a.c. track circuits must be used. These require expensive impedance bonds because they have to be sufficiently large to carry the relatively high currents associated with d.c. traction ; nor can bond size be reduced significantly for higher-voltage d.c. systems because, for a given train density, the track currents are not appreciably reduced on account of the wider substation spacing admitting more trains. If only one running rail is used as a conductor on d.c. traction systems (as on the Italian 3kV system) permitting single-rail a.c. track circuit to be used and impedance bonds to be omitted, it may be necessary to parallel the continuous rail with an earth conductor. This

will assist track conductivity and reduce rail current density, which, at high values, may saturate the track circuit equipment at the relay end.

On standard frequency electrifications steady-energy single-rail d.c. and single or double-rail a.c. track circuits may both be used, provided that in the case of d.c. track circuits the rails are free from extraneous direct currents. These d.c. track circuits use a special d.c. track relay which is immune from standard frequency traction currents. If the feed is from primary cells these may be choke protected, but if a rectifier is used at the feed end precautions must be taken to prevent half-wave rectification of traction currents, which could cause a rise in the applied d.c. track voltage and affect the operation of the train shunt. Equipment has been developed for this purpose which does not depend on filter circuits for security. Where trickle-charged secondary cells are used to feed tracks these may be charged and discharged with an automatic change-over device.

Wherever a.c. track circuit is used on a.c. traction systems the signalling current frequency must differ from the fundamental and harmonics of the traction system frequency, and a safe frequency discriminator must be installed at the relay end. It is possible to satisfy these conditions by incorporating a rectifier in circuit after the discriminator and using standard d.c. track relays. The feed ends may be supplied from local static frequency converters, and compact 75 c/s equipment has been developed both here and abroad which is suitable for use on standard frequency electrifications. Where double-rail a.c. track circuit is used the impedance bonds may be much smaller than those required for d.c. traction systems on account of the lower track currents.

Audio or " musical " frequency track circuit has been under development for some time and has recently been installed on the standard frequency electrification in N.E. France. This operates with 1 kc/s carrier modulated at 20 c/s. The high carrier frequency permits a reduction in the number of impedance bond turns with some further saving in size and cost, although it demands a greater energy input owing to rail attenuation.

Where new track circuits are installed on standard frequency traction systems there are therefore three alternatives to choose from, namely, special single-rail direct current, single or double-rail alternating current at suitable frequency and the " musical " track circuit requiring electronic equipment. The choice of modification to existing track circuits will be governed by their type. It is, however, significant that d.c. track relays, which are widely used on steam-operated lines, may be retained after standard frequency electrification provided that the tracks are fed with alternating current. This will eliminate battery maintenance.

Electrification project studies, made by the authors, which included provision for new signalling installations as well as conversion of existing ones, revealed that the cost of this work was not affected to any marked extent by different traction systems.

Economic Considerations

The justification for adopting the standard frequency system of electrification must, of course, stand or fall upon its being the cheapest method of providing the necessary service. Having decided on the technical features required for any project, it is a matter of step-by-step procedure to estimate the costs of the fixed equipment and rolling stock for any system of electrification. As has already been mentioned, wide differences may be disclosed in the estimates for alterations to ways and works, depending on the topography of the line, while the distribution system estimates may also vary depending upon the layout of, or the plans for, developing the power supply system. In some cases the cost of providing transmission lines and even substations may be included in the tariff charged by the electricity supply authority ; in other cases (now not very frequent) the railway has to provide a generating station as well as substations and distribution system. Tariffs for the electricity supply will be influenced by the cost of coal or the availability of hydro-electric power, and when electrification is compared with diesel operation the cost of fuel may become the most significant factor.

In any economic comparison between electric and steam (or diesel) traction the capital cost of electrification is greater than the other alternatives, but the annual savings in operation and maintenance may exceed the interest and depreciation charges on the higher outlay. However, when different systems of electrification are being compared the differences between the operating and maintenance costs of each system are small. Consideration of the capital expenditures in each case, therefore, becomes the important factor.

Table IV gives the annual costs on a comparative basis of four system studies made by the authors for a 300 route-mile project of low traffic density. The figures include allowances for changing the location of staff quarters and modifications to maintenance depots as required by the electric services. It will be seen that the difference in costs between the three systems lies mainly in the capital charges and that the operation and maintenance totals vary only a little, and even then in the same direction as those of the capital charges. These studies disclosed that, for the project in question, the standard frequency system is 12 per cent cheaper than the nearest d.c. alternative (3kV) and 28 per cent cheaper than 1·5kV d.c. These results arise almost entirely from differences in capital cost of track equipment and substations, which together comprise nearly half the total and which are 50 per cent more expensive than in the a.c. alternative. The only item for which the a.c. alternative is the more costly is for alterations to ways and works, where it is 12 per cent dearer.

TABLE IV—*Comparison of the Annual Costs of Railway Electrification of a 300-Route-Mile Project with Different Systems*

	1500V d.c.	3000V d.c.	16⅔ c/s a.c.	50 c/s a.c.
Power	11·5	11·4	11·7	11·8
Operation	22·8	22·9	24·4	22·5
Maintenance	20·2	18·8	18·1	17·5
Total (running)	43·0	41·7	42·5	40·0
Interest	61·5	48·7	41·7	39·4
Depreciation	12·0	10·2	9·1	8·8
Total (interest and depreciation)	73·5	58·9	50·8	48·2
Grand totals	128	112	105	100

The authors have not had occasion to make a project study of an existing main line having a high traffic density, but it seems likely that the standard frequency system will be the cheapest method of electrification in this case also. Although the quantity of rolling stock will increase corresponding to increases in traffic density, the unit cost of locomotives is just about the same for alternating and direct current ; rolling stock costs would not therefore affect the comparison, whatever the traffic density. Of the fixed equipment, the number of substations will tend to increase with an increase of traffic (although by no means in proportion), but the cost of a.c. substations will still be less than d.c. ones. The cost of track equipment depends rather on the single-track mileage to be equipped than on the traffic density, but the a.c. alternative is always much cheaper. As already mentioned, the only item which handicaps the a.c. system is the cost of the alterations to ways and works. The amount of this depends on the number of tunnels, bridges, &c., which infringe the required clearances, but the difference in favour of direct current seems likely to be small, and in neither case is this expenditure affected by increases in the traffic density. These views are supported by the published results of a French study embracing a group of routes of average traffic density of about 9,000,000 ton-miles per annum per single-track mile.

Finally there is one matter which has perhaps not been squarely faced in comparing the estimates, namely, the question whether, with d.c. electrification, it is necessary to cable the communication circuits if these are open-wire lines. Views on this have already been expressed, but it has to be admitted that it is theoretically possible to use open lines in the d.c. case. However, even an expenditure of some £5000 per route-mile on this account would still not have been sufficient to tip the balance in favour of direct current in the low traffic density projects discussed. Its effect would be less significant still in a high traffic density case.

It is not inferred that this relationship between traffic density and system of traction may be applied with impunity into the suburban range, where trains have to be run at the shortest possible headway for which the line can be signalled. Under these conditions, for security reasons, it is prudent to increase the capacity of the fixed equipment, particularly the substations, beyond electrical requirements ; this will reduce the margins. Alternating current multiple-unit stock may be more costly than the d.c. version, particularly if limitations are imposed by gauge, platform height, or axle loading. Also, expenditure on rolling stock is likely to form a much larger percentage of the total cost because sufficient multiple units must be purchased to operate the peak traffic, and their utilisation may therefore be poor compared with that of locomotives working a main line service. Furthermore, in built-up suburban areas the cost of the distribution system may be increased by the necessity for cabling, and the ways and works modification costs are almost certainly likely to be increased by the existence of tunnels and overbridges, even to an extent that a current rail system becomes imperative.

At the other extreme, where traffic is very light and especially if conditions will not permit the working of large annual locomotive mileages which are possible after electrification, the operating and maintenance economies resulting from electrification may be swamped by the capital charges in respect of the fixed installation. In such a case, even electrification at the standard frequency could only be justified, if at all, as a means of facilitating through working and thereby increasing the savings on neighbouring lines which had already been equipped for electric operation. Where this does not apply and traffic is very light, consideration must be given to diesel working as an alternative to electrification, even if only as an interim measure.

The fact that standard frequency electrification is cheaper than alternative systems has a major bearing on the question whether or when it will pay to electrify rather than convert to diesel operation. High traffic density favours electrification because more rolling stock is required, and, for a given performance, diesel rolling stock is more expensive than electric. With low traffic density the high cost of the fixed equipment militates against electrification, but since this cost increases only slowly with increasing traffic and the operation and maintenance costs are no greater with electric than with diesel traction, there exists a traffic density at which the total annual costs (including capital charges) of the two forms of motive power will be equal. It is not possible to generalise on the traffic density at which this will occur, since it involves, among other things, the price of diesel fuel and tariffs for electrical energy, both of which vary widely for different circumstances. In one investigation made by the authors the costs balanced at about 8,000,000 trailing ton-miles per annum per single-track mile, while in another it was about half that figure. In both cases the figures would have been much higher with d.c. electrification.

Apart from the issues discussed, the overall economic aspect must be considered in relation to the need to step up efficiency by increasing track capacity. Electrification in combination with suitable signalling can contribute far more in this respect than any other form of traction. As a national policy in order to conserve coal or to utilise hydro-electric or atomic sources of power and to avoid substantial increases in oil imports, railway electrification requires no justification ; it should be proceeded with as quickly as possible. Wherever electrification has been introduced the operating departments and the public have been appreciative of the services and the amenities it provides.

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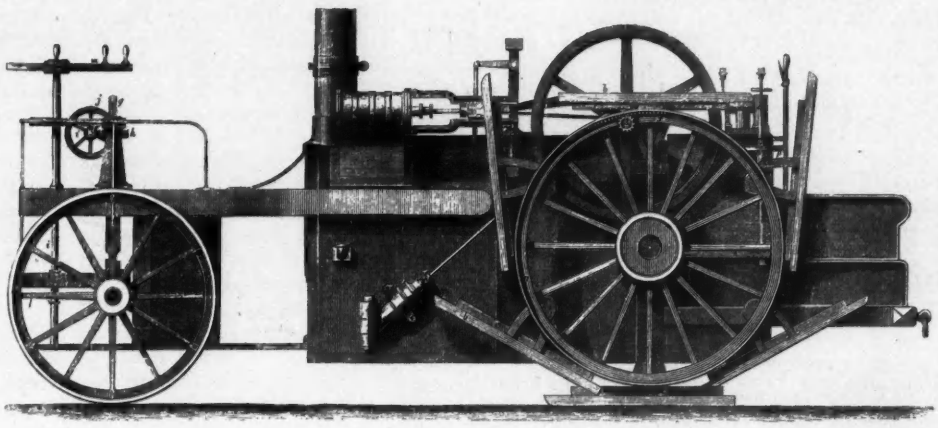
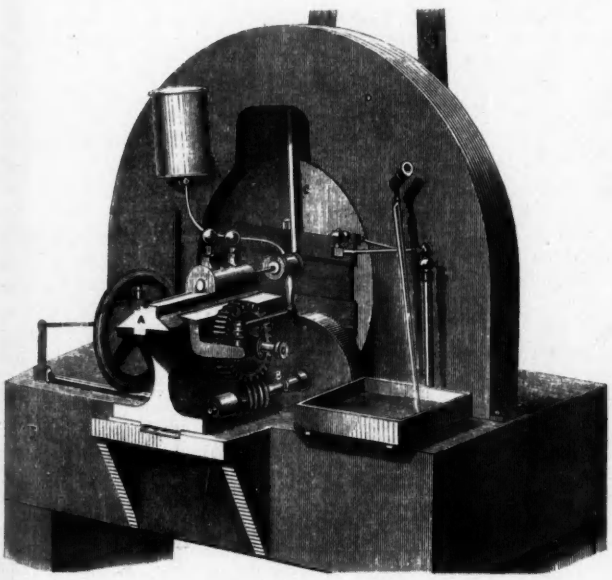
[3] Ames, E. W., and Dowden, V. F.: " Ignitron Multiple-Unit Cars for the New Haven Railroad," *Applications and Industry*, 1955, page 147.

Engravings of 1859

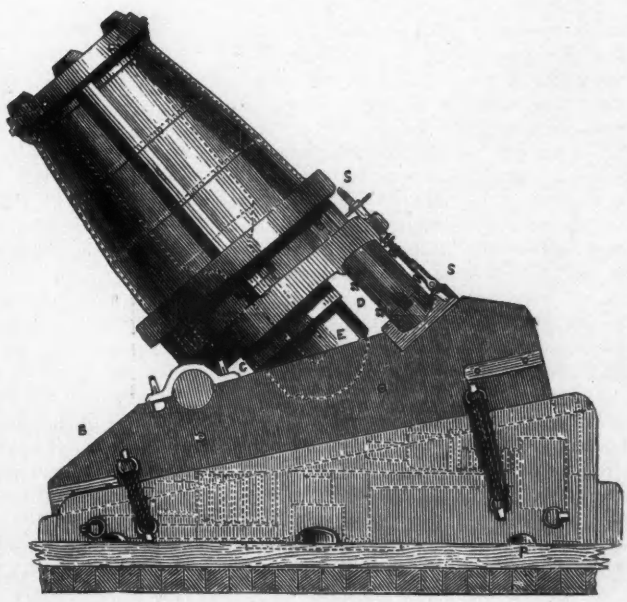
Some improvements to traction engines made by Charles Burrell, Thetford, Norfolk, were noted in the issue of July 8, 1859, from which this engraving is reproduced. The improvements related to "the system of employing shoes with A-formed bars to construct portable railways for the wheels to run on." It was pointed out that this system was "similar to that known as Boydell's." The "boiler and engines" were mounted in such a way that the pinions on the main shaft, by being raised or lowered, could "be caused to gear with or be separate from the teeth of the cog-wheels fixed to the main or hinder wheels of the carriage."





On the left there is shown a "machine for boring the sockets of bayonets," which was illustrated in a description of the Royal Small Arms Factory at Enfield, published on June 3, 1859. The machine consisted of a face-plate, to which the bayonet was fixed, by means of a pair of clips which were screwed together, with its socket coaxial with the spindle on which the plate was fixed. Our description continued: "This is covered over with a guard of sheet iron, so as to preclude the possibility of the point of the bayonet, as it revolves, doing any injury, even in its crude and unfinished state."

The engraving below, from our issue of February 4, 1859, shows a 36in mortar, which was described in a lecture on "The Military and Naval Uses of Very Large Shells," delivered to the United Service Institution by Mr. Robert Mallet. The mortar was built at Woolwich Arsenal, its weight being about 52 tons, including the bed. Part of the description reads: "The heaviest single segment is the base, which weighs about eleven tons, the chamber piece about eight tons, and the segments of the chase from six tons to about two tons respectively. When put together the segments are united by six longitudinal bolts, with the muzzle ring and base. The chase is 2½ calibres long nearly. The chamber is deep and narrow, and was made to hold 120 lb of powder. The vent is at the rear in the metal of the chase, on the level of the spherical cup or seat of the shell, and the powder is fired by a Bickford fuze, passed in, through, and under the shell to the powder—or, if desirable, by the galvanic wire. It is thus fired from the top of the chamber, in order to give it longer time to burn, for which purpose also the charge is placed in separate 10 pound bags of flannel, in one of which the end of the fuze is choked, and which fires the rest. The mortar is capable of elevation or depression 10°, or from 40° to 50°, angle of elevation."



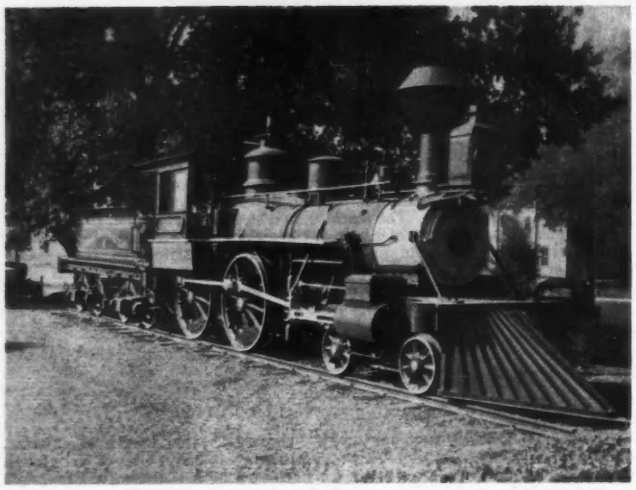
LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

A NOTABLE AMERICAN HISTORICAL LOCOMOTIVE AND AN ICE LOCOMOTIVE

SIR,—I was extremely interested in the beautiful engraving of 1857 reproduced in your issue of January 27th showing the very interesting American 4-4-0 wood-burning locomotive of that period. This fine engraving has prompted me to send you the accompanying photograph showing a notable



The Southern Pacific Lines, locomotive "Sabine," built in 1854 by the Niles Locomotive Works, Ohio

American historical locomotive, the "Sabine," of the Southern Pacific Lines. The engine is a wood burner, and is shown on exhibition and in most excellent condition at the Southern Pacific Company's depot at La Fayette, Louisiana, in August, 1941. The "Sabine" was manufactured by Niles and Co., of the Niles Locomotive Works, Cincinnati, Ohio, in 1854, and was the first locomotive to haul a passenger train into La Fayette, La, in 1880, when the town was known as Vermillionville. The engine was afterwards sold to a sugar refinery, where it was employed for several years in connection with the hauling and transport work at this plant. In the late 1930s, the engine's historical value was realised and the Southern Pacific Company brought it back to their shops at Algeria, La, where it was overhauled and reconditioned for permanent preservation as a locomotive of historical interest. Unfortunately, however, during the war years, the urgent need for war scrap became vital, and the "Sabine" was finally donated to the U.S. for this purpose in December, 1942.

The illustrations and descriptions in your issue of January 27th concerning the "Ice Locomotives" of 1861, were exceedingly interesting. It may interest you to hear that in *Cassell's Magazine*, Vol. VI, at page 126, there appears an engraving showing a somewhat similar type of ice locomotive, which is referred to as a steam sledge. It would appear that this engine was built much later than 1861, and outwardly resembles one of the 2-4-2 inside cylinder, side-tank locomotives which were popular on the railways of this country from 1870 onwards. No date of construction of this locomotive is given, but it was designed by Mr. J. W. Cayser, of 50, Lansdowne Gardens, Clapham Road, London, for operating on ice or frozen ground in Canada or other cold countries where sledges and ice boats were the usual means of transport at that period. The description of this locomotive is given as follows. "It is simply a tank locomotive with its leading and trailing wheels replaced by skids of iron at each end. There are a pair of single driving wheels in the usual position which have projections on their tyres to enable them to grip the ice, and the engine is guided by a steering wheel in the driver's cab which directs the leading skids. The boiler is thickly mantled in felt and wood to exclude the cold. Cast iron is avoided as much as possible in its construction, so as to lessen the chances of fracture by brittleness due to the low temperature. The engine men are completely sheltered, an all-over cab with revolving shutter doors being provided at the entrance. Such an engine, if made thoroughly practicable, would, of course, do many times the work of the ordinary horse conveyances now in vogue." Unfortunately, *Cassell's Magazine*, Vol. VI, does not give any date of publication of the volume, and no details regarding the principal dimensions of the locomotive are given.

A. J. RICHARDS

Tyseley, Birmingham,
January 28th.

A NEW INSTITUTION?

SIR,—I refer to the letter to you, from Mr. Graham Ball, of Bilborough, Notts, published in THE ENGINEER, January 20, 1956, page 98. He apparently requires, or is looking for, an Institution for rising young engineers, to bridge the gap between H.N.C. and the senior professional institutions. Has he never heard of the "Junior Institution of Engineers," founded in 1884 by apprentices at the Lambeth works of Maudslay, Sons and Field, of London? It has grown throughout the years, with many still active members of fifty years standing, and eighty years old. The "Junior Institution of Engineers" caters especially for young apprentices, craftsmen, and engineers of all branches. One of the outstanding features is the range of subjects covered by the lectures and papers read before the meetings —nuclear power reactors—bridge building—sewage — instruments — dams — oil and petroleum technology—plastics—electronics —heating and ventilating—electrical, &c., boosted by films and film evenings, and monthly visits to reputable works or installations. Our members are spread round the world, with corresponding members in many countries. In this country the headquarters are close to Victoria Station, London, while provincial sections for the "Midlands," "North-Western" and "Sheffield" are at Birmingham, Manchester and Sheffield, respectively. Our *Journal* now celebrating its jubilee, is produced monthly, containing papers given at lectures and a record of *Transactions*. Every four years the Gustave Canet Memorial Lecture is held at H.Q., London. In conjunction with the Maudslay Society the annual Maudslay Scholarship is awarded on a competitive basis. The Institution also runs an annual competition known as the "Durham Bursary," carrying with it the main prize of £20 cash.

Practically every member has found the "Juniors" a sure foundation and stepping-stone to the academic professional institutions and do everything they can with advice or information to help young students or associate members, backed by a H.Q. library containing 5000 technical books and well supplied with trade publications. The Institution also runs an authorised employment register. The London H.Q. have a large, quiet, comfortable library and reading room, while the lecture hall is one of the best in London, well equipped with up-to-date apparatus, including projectors for slides or film strips, epidiascope and 18mm sound/silent film projectors.

This is the institution that Mr. Graham Ball is looking for or has in mind for young engineers. Perhaps he would join our ranks and become a "Junior," where his enthusiasm to help young engineers would find plenty to do and would be greatly appreciated. He would be very welcome should he manage to visit our Institution. Our secretary, Mr. G. W. Germaim, would be only too pleased to forward more detailed information.

S. A. MCAULIFFE

3, Newnham Avenue,
Field End Road,
Ruislip, Middlesex.
February 1st.

SIR,—I would like to ask Mr. Ball, who suggested an institution for technical engineers, whether any engineer could at all be non-technical. Furthermore, since associate membership normally carries corporate status why does he list the exempting "qualifications necessary for associate membership" and then say that corporate membership could be "obtained only by external examinations with no exemptions"? The qualifications, i.e. G.C.E., O.N.C., H.N.C., &c., surely speak for themselves, and since he makes no mention of any stipulations covering practical experience, membership of this proposed institution could indicate nothing else but the possession of the certificates

listed. Surely the best evidence to produce in proof of the award of a certificate is the certificate itself. Mr. Ball's insistence on Latin as a compulsory subject is intriguing. Perhaps he would care to ponder on the meaning of our motto : *Progressi Providendo Progredimur.*

W. E. WALTERS,
General Secretary,
Institution of Engineering Designers.

London, W.1., January 27th.

Literature

Law and the Engineer. By CHRISTOPHER F. MAYSON. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 63s.

"THE aim of this book," according to the author's preface, " is to present to engineers, in a practical and understandable manner, certain aspects of the law as are likely to be of interest or concern to those engaged in the design, manufacture, sale, installation, maintenance and repair of all kinds of engineering equipment." To turn the engineer into a lawyer is not the author's object. He probably had in mind the maxim :

> One science only can one genius fit
> So vast is art, so narrow human wit

a generality to which, of course, there are notable exceptions. An engineer is not expected to be also a lawyer, but, as the author states (on page 393) : " A consulting engineer is expected to have a practical working knowledge of the law so far as is likely to affect the work for which he is responsible to his principal," and so, if he is an electrical engineer, he must know and understand the Electricity Supply Regulations ; if his interests are mainly mechanical, he may have to have a working knowledge of the Factories Act, 1937, and the countless regulations made thereunder.

Let us see what the book contains. Part I embodies a brief description of the English Legal System. In Part II there is a summary of the law of contract ; Part III contains an outline of the law of negligence, notes on the responsibilities of occupiers of premises and employers ; a useful summary of the Factories Acts and the regulations made thereunder ; a special treatment of the regulations concerning electrical safety, and a discourse on compensation for personal injuries. The responsibilities of professional engineers are treated of in Appendix I. The standard conditions of engineering contracts are summarised in Appendix II, and the Factories Act, 1937, and various other relevant statutes, in Appendix III.

With regard to the matter contained in Parts I, II and III, it appears to be an admirable summary of so much of the law of England as would interest an engineer. Take one example at random. The Standard Conditions of Engineering Contracts (which are outlined on pages 395 to 402) naturally include the penalty clauses which are often a source of trouble to the contractor who has to work to time, and to the engineer. To what extent and in what circumstances can a penalty be imposed ? This question is well answered on pages 182 to 184, where it is made plain that, although to all appearances, if there is delay, the contractor is liable to pay a large sum by way of damages according to the words of the contract, the amount which can be exacted may be comparatively small.

The law relating to the responsibilities of professional engineers is clearly and succinctly stated in Appendix I. As the author says (on page 392) : " In common with other professional persons, a consulting engineer is bound to bring to his task that care, skill and competence which is generally recognised as being in accord with ordinary standards." He will therefore be liable for negligence. Although the author does not mention any case in which an engineer was found guilty, or even accused, of negligence, there are such cases : some of them are noted in *Kempe's Engineers Year Book* (1955) at page 1278. When dealing with " evidence " the author makes special mention of the expert witness, pointing out that while an expert is usually called to explain technical matters to the Court, he is also allowed to express his opinion, a privilege not accorded to the ordinary witness. Sometimes it will be for the judge to balance one such opinion against another. In a case (not reported) of which the present writer has some knowledge, many engineers, called as experts, gave evidence. Just before the end of the hearing the learned judge asked one of these witnesses to come back into the witness box and said to him : " Now, Mr. ....., you said in the course of your evidence that, &c. (quoting from his note of what the witness had said). Is that your real opinion ? " " Yes, my lord," said the witness. When giving his reserved judgment, the judge made it plain that he had adopted that evidence in its entirety. It is noteworthy that now (by virtue of 0.37, r.I(E) of the Rules of the Supreme Court) in cases arising out of an accident on land due to a collision or apprehended collision, the expert evidence of an engineer is specially dealt with. Such evidence cannot be received unless a copy of a report from him containing the substance of his evidence has been made available to all parties before the hearing, and an order is made authorising the admission of the evidence.

The author gives one timely warning to the man who is called as an expert. He points out (on page 32) that our judges " acquire quite an appreciable understanding of technical matters in the course of the cases they try over the years." Not only that, but some of their lordships, who have never had any scientific training evince a remarkable aptitude to learn. Lord Morton, who is now a Lord of Appeal, when sitting some years ago as a judge of first instance, had to try a case which related to a complicated system of railway signalling. He opened the proceedings by informing the counsel that he knew nothing about electricity. The hearing lasted many days, at the end of which the learned judge delivered a judgment in which he evinced a complete mastery of the subject. And there was no appeal from his decision.

Tables of relevant statutes, statutory regulations and decided cases referred to in the text conclude a volume which every engineer will find it useful to have on hand.

How Time is Measured. By PETER HOOD. London : Geoffrey Cumberlege, Oxford University Press, Amen House, Warwick Square, E.C. 4. Price 10s. 6d.

THIS is the fifth volume of a series dealing with subjects connected with science and natural history, and designed to present the matter in a simple way which can be easily understood by those having little knowledge of the subjects. In this volume a large number of illustrations and drawings are used with clear, concise descriptions to provide a comprehensive introduction into the subject of time-keeping, and to give a basis on which the interested reader can extend his knowledge by subsequent reading of more advanced text books. It opens with notes on the origin and perfection of the calendar and then goes on to describe, step-by-step, the development of means of time-keeping from sun dials up to the present high-precision quartz-crystal clock. The use of a large number of drawings, diagrams and illustrations will be of considerable assistance to the reader unfamiliar with the basic mechanisms of time-keepers. The book concludes with a useful bibliography of more advanced text books on the subject of clocks and watches and their manufacture, repair and history.

The author is to be complimented on producing an excellent introduction to the subject of time-keeping. It provides a useful addition to the libraries of those who, although not directly concerned in the time-keeping industry, are interested in the subject from the historical angle or as amateur horologists.

Tables of the Cumulative Binomial Probability Distribution. By the STAFF OF THE COMPUTATION LABORATORY OF HARVARD UNIVERSITY. London : Geoffrey Cumberlege. Price 63s.

THIS volume, thirty-fifth of the Annals of the Computation Laboratory of Harvard University, is the first to be computed with the Mark IV Calculator. It gives to six decimal places values of

$$\sum_{x=r}^{n} \frac{n!}{x!(n-x)!}(1-p)^{n-x}p^{x},$$

representing the probability that at least " r " successes will occur in " n " independent trials each with probability of success " p." The introduction contains a discussion of several applications of the function and of its mathematical background. The tables have been arranged to be useful to persons other than the professional mathematician : fractional as well as decimal values of the probability parameter are used. An appendix is a table of $\log_{10} n!$ for " n " up to 1199.

Automobile Electrical Equipment. Fifth edition. By A. P. YOUNG and L. GRIFFITHS. London : Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 25s.

THIS compact volume essays a complete survey of electric lighting, starting, ignition and control equipment on the internal combustion engined vehicle. The latest edition has been extended to cover numerous recent innovations, such as P.S.V. door actuators, and there is an excellent treatment of a.c. motor-cycle installations. Omissions, however, include self-parking and two-speed windscreen wipers, remote indicating temperature and pressure gauges and fully automatic over-drive control systems. Those parts of the work dealing with theory are generally disquieting : the electro-chemical reason postulated for earthing the positive battery terminal is, at the least, unconvincing. The description of double-lever contact breakers is inconsistent and in error, and should be illustrated with a Mallory equipment. Dynamotors, despite their use on vintage cars and modern motor-cycles, are dismissed in two lines. We would be inclined to date the dominance of coil ignition from earlier than 1940, and are pleasantly surprised to learn that the price of silver-zinc accumulators is competitive with that of heavier types. The illustrations are often illuminating. For a book which, despite these criticisms, automobile engineers will like to have on their shelves, it is very unfortunate that the index is inadequate.

Marine Reduction Gearing

By A. W. DAVIS, B.Sc.

No. III—(*Concluded from page* 159, *February* 3*rd*)

At the Institution of Mechanical Engineers on January 20th, Mr. A. W. Davis, who is deputy managing director, Fairfield Shipbuilding and Engineering Company, Ltd., Glasgow, presented the twenty-eighth Thomas Lowe Gray Lecture. We reprint here the greater part of the Lecture exclusive of appendices that accompanied it.

Tip Relief

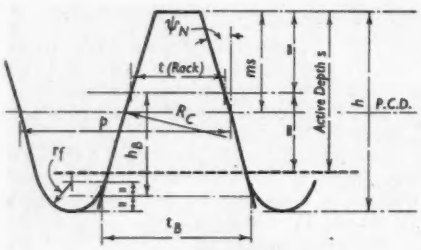
WHILE the desirable values of the foregoing criterion numbers have been assessed from practical experience of gears on trial and in service, based on a high quality of tooth finish, certain refinements may justify the raising of some limits and the question of the best tip relief to be provided for the teeth is silhouetted against any such consideration.

Before referring in detail to the extent of tip relief required it is essential to refer to two features that have been responsible for confusion.

First, tip relief on a spur gear (Merritt, 1954) is necessary to provide " sweetness " of engagement in compensating for the deflection of the load-carrying teeth. The comparable feature in a helical gear is the relief that must be provided at the ends of the pinion teeth ; no such consideration arises affecting tooth profile. Secondly, because gears have sometimes been designed in a manner that has made them susceptible to scuffing, an erroneous impression has arisen that heavy tip relief is a basic necessity of normal engagement of helical gear teeth, in disregard of the palliative nature of the measure.

In extreme cases the tip relief has been progressively increased to amputate tooth surface and when the measure has not been carried sufficiently far to overcome scuffing it has been described as inadequate with reference to the thickness reduction rather than the radial dimension of mutilation. With a gear tooth properly designed to meet the requirements of the transmission, the factors dictating the need for tip relief are entirely different.

Attention is now directed to the measurements described in an appendix, in which the values of factors *a*, *b*, *c*, *d*, *e*, and *f* represent the variation in loading intensity along the line of contact. Typical values of the factors are plotted in Fig. 14 as applying to a pair of teeth of $^{8}/_{10}$in pitch having $\psi_N = 16$ deg. and $s/p = 0{\cdot}76$ with a length of contact corresponding to a helical angle of 30 deg. The nature of the variation corresponds to a forecast envisaged by Walker (1946), but appears to be of lesser total variation than he anticipated, being for this form of tooth plus 60 per cent and minus 20 per cent of the average load, totalling 80 per cent. Corresponding variations and percentages measured for a tooth of the same pitch having $\psi_N = 22\frac{1}{2}$ deg. and $s/p = 0{\cdot}636$, total 95 per cent. For the $^{7}/_{10}$in pitch deep tooth with $\psi_N = 14\frac{1}{2}$ deg. and $s/p = 0{\cdot}915$, the total variation in load is 65 per cent.



SECTION NORMAL TO TOOTH.

p_f Pitch fitted (if differing from desirable or theoretical pitch).
σ Helical angle. ψ_P Pressure angle in transverse plane.
z Tangential length of contact zone in transverse plane.

Fig. 13—Symbols for tooth dimensions

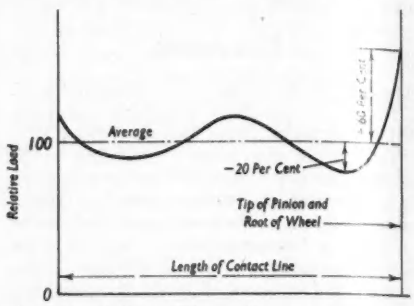


Fig. 14—Typical bend variation on contact line

In an appendix reference was also made to the corollary to be drawn from the deflection calculations by assuming *a*, *b*, *c*, *d*, *e*, and *f* to be equal, giving differing local deflections that might be regarded as the mirror reflection of an initial profile correction to give uniform loading. But the total correction to give the required effect is only 0·00005in. The importance of this finding is that the whole conception of correcting the involute to compensate for the not inconsiderable variation in loading that nominally occurs by reason of tooth deflection due to bending and shear, is, with a helical gear, purely theoretical and incapable of practical interpretation. It nevertheless emphasises the value of plasticity in the running-in of a new gear.

The sole legitimate reason for profile correction is to provide for the generation of a hydrodynamic oil film at the regions of initial and final contact and this is effected by a tip relief of, say, 0·00025in plus an allowance to compensate for Hertzian depression (which, unlike bending and shear deflection, tends to absorb tip relief effect). The total relief to be provided varies then from, say, 0·0003in for a 0·4in pitch to 0·0005in for 0·8in pitch.

The problem of producing these small corrections naturally requires patient attention. In shaving, the requirement is met by a swelling on the root of the cutter profile of about twice the desired relief, the ratio having been established by comparing the routine measurement of a shaving cutter profile with the profile of a tooth finished with the same tool, and obtained laboriously in the interest of research.

Finishing by hobbing does not provide assurance that the correction will be properly achieved. Two fundamental difficulties obtrude. First, there is the difficulty of a

Symbols

Symbol: Having application in final conclusions	Symbol: Having permanent application in detail	Symbol: Used only for convenience of expression	Meaning (lb-in units unless otherwise stated)
Gear proportions :			
		B	Breadth of one helix
D			Pinion P.C.D.
D_g			D [gear ratio/(1 + gear ratio)]
G			Gap between helices
		I	Moment of inertia of pinion section
		L	$\frac{1}{2}$ (effective length between pinion bearing centres)
W			$2 \times B$
W'			Theoretical optimum value of W for minimum load concentration
Bearing dimensions :			
D_b			Journal diameter
d			Diametral bearing clearance in $^{1}/_{1000}$in
Loads, forces and pressures :			
		F	Reaction on one pinion bearing
P			Average tangential load per inch gear face (based on $(W-2)$ inches)
		P_b	Bearing pressure on projected area
		P_f	Pressure in oil film between teeth
	P_m		Maximum value of P
		P_N	P converted to force normal to tooth
Stresses :			
	S_H		Hertzian stress (conventional)
	S_P		Hertzian stress (see Appendix XII)
	S_R		Root bending stress
	U		U.T.S. of pinion material, tons per square inch
Speeds :			
N			Pinion speed, r.p.m.
		V_s	Tooth sliding speed (relative)
		V_R	Tooth rolling speed (relative)
Criterion numbers and factors :			
C'			Gear loading C factor, ' indicates incorporation of material constants
C_D	c_d		Pinion distortion multiplying factor (about 1·0 for well-designed gear)
		C_P, k_P	Criterion of Martin oil film pressure
		C_H, k_H	Criterion of Hertzian stress
C_P', k_P	k_P^*		Criteria of pitting, root stress, and scuffing respectively
C_R', k_R	k_R^*		$C_P = K \cdot k_P$, &c. and $C_P = K \cdot k_P^*$, &c. — * indicates use in particular comparison
C_S', k_S	k_S^*	c_s	
C_{MP}			Material constants representing effect on resistance to pitting, root fatigue, and scuffing respectively for materials other than current standard materials
C_{MR}			
C_{MS}			
K			Conventional K factor P/D_g
Common symbols used in mechanics :			
		E	Modulus of elasticity
		e	2·718
		λ	Poisson's ratio
		μ	Viscosity (relative)
Sundry functions and coefficients :			
		A	Local significance (Appendix III)
		a	Local significance (Appendix III)
		b	Local significance (Appendix III)
	δ_{BN}, δ_{BT}		Normal and tangential deflections of a pair of teeth due to bending and shear
	δ_{HN}, δ_{HT}		Normal and tangential deflections of a pair of teeth due to Hertzian compression
δ_T			Combined tangential tooth deflection, inches per pound per inch load
		f	Thickness of oil film between teeth
		H	Local significance (Appendix II)
		J_s	Local significance (Appendix IV)
		l_f	Effective length of loaded oil film between teeth
Q			Tooth proportion factor for estimation of δ_T
		t_A	Local significance (Appendix III)
		x	Local significance (Appendix III)
	X_Q		Root fillet stress raiser
	X_S		Stress modifier for helical teeth
	X_σ		Function of helical angle that affects root stress
	Y		Function of tooth form (equal to 1·0 for consistent series)
	y		Function of angularity of line of contact as it affects tooth deflection
		y_A	Local significance (Appendix III)

Tooth proportions and angles, see Fig. 13

slightly eccentrically-running hob already referred to, producing errors, even under most careful control, greater than the required correction. Secondly, the generating process is such that the position of the swelling on the hob tooth to give proper tip relief varies with the diameter of the gear to be cut, and unless a much greater relief is to be accepted for large diameters with loss of effective tooth surface, a considerable stock of only slightly differing hobs must be carried.

End Relief

End relief to be greater than the total tooth deflection and depression should be, say, 0·0005in for 0·4in pitch to 0·0015in for 0·8in pitch, normal to the teeth on both flanks. The relief is solely to provide smoothness of entering engagement and, this in itself being ensured, root strength is adequately safeguarded by the conventional chamfer and the fact that the enhanced flexibility of the tooth end does not permit that part to carry more than a reduced load relative to the body of the tooth, the total deflection all the way along being naturally constant and productive of uniform stress. The provision of this slight relief, which should wash away in about ¼in, can form part of the selective shaving process. Excessive end relief is detrimental in just the same way as excessive tip relief. The author does not consider that there is any useful purpose to be served in attempting to make this small relief taper off in line with the line of contact in a manner which has been suggested and which entails costly work on every wheel tooth.

$(W-6s)$ is employed rather than W in the calculations for tooth loading, not because the teeth are relieved for $1 \cdot 5s$ inches at each end, but because this allowance represents the reduction in load carried by the ends of the teeth regardless of relief.

Dynamic Magnifiers

In referring to the application of tooth-loading criteria, attention was drawn to the amplification of tooth loading by exceptional cyclic irregularities of torque and it is not the intention here to refer in any detail to this highly involved subject. Such irregularities are always present to some degree in the working range of speed, and, with the effects of weather, account for the more arduous conditions of gear operation on board ship as compared with the test bed, necessitating factors of safety in relation to which test-bed records can be misleading. Conditions can be particularly difficult when the machinery is placed aft in a ship, due to the relative rigidity of the shafting. Very substantial amelioration of these conditions has been obtained by the use of five-bladed propellers on such single-screw vessels, this being without loss of efficiency and possibly even with some advantage.

Rigidity of thrust-block seatings is important having particular regard to shear deflection which is so often neglected and which can be compensated only by thickness of fore-and-aft plating. A well-ribbed structure of relatively thin plating can appear misleadingly strong in this particular connection.

Couplings and Their Effect on Gear Performance

Vibration measurements of flexible coupling teeth carried out with the aid of Piezo-electric pick-ups associated with a cathode-ray oscillograph indicated on one vessel the build-up with power of a disturbance at coupling-tooth frequency brought about by the out-of-alignment of primary wheel and secondary pinion when taking up the load position in their respective oil clearances (resulting in localised contact on a diametral line across the coupling teeth).

A similar disturbance was not observable when a sister vessel was tested under similar conditions with couplings of identical construction, but with the alignment between the primary and secondary gears modified to give concentricity in the ahead running position and it is recommended that primary wheels and secondary pinions be aligned in this way, and that double the alignment error be accepted going astern.

Such an arrangement is also to be preferred when no sliding coupling is fitted so as to minimise any offsetting bending moment on the gears in the ahead direction of rotation.

Sliding couplings when fitted to a quill shaft are, as their name implies, intended to allow a shuttling of the secondary pinion without any restriction from the inertia of the primary gears. But when heavy torque comes on a coupling it does not slide readily and damage has been experienced to the axial locating faces of primary wheels due to an excessively flexible main thrust seating, the axial load through the gears providing an indefinite maldistribution of torque between the two helices of the secondary gears.

No fretting has been experienced with small toothed couplings having claw teeth thinned towards the ends and lubricated centrifugally through holes drilled to the roots of the teeth, the materials being nickel-on-carbon steels. The latest development is to apply the Sulphinuz process to the claws after cutting the teeth, the distortion under treatment being negligible, and it may be that this process will eliminate the necessity for the use of an alloy steel in one of the elements. This should have the effect of maintaining the units immune to fretting and reducing the coefficient of friction between the teeth, making the coupling more ready to slide. Similar treatment is being applied to turbine couplings.

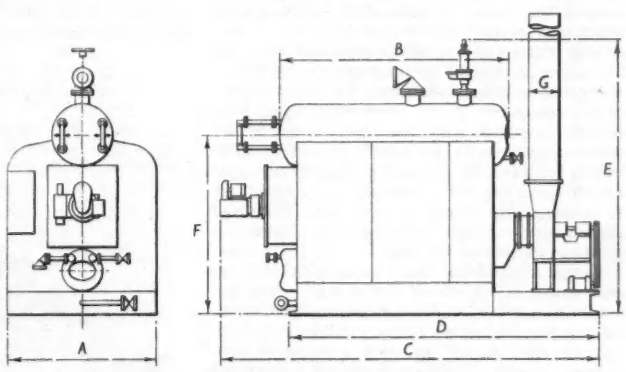
Packaged Boilers

The range of boilers manufactured by Davey, Paxman and Co., Ltd., now includes the "Keystone" water-tube boiler of American design. These units have evaporation rates rising from 2500 lb to 17,000 lb per hour and the smallest unit weighs 10 tons, while the largest unit weighs 26½ tons. Another boiler, also of American design, being constructed by the company is the "V.L." two-drum water-tube boiler which can be fired by solid fuel, oil or gas.

At the invitation of Davey, Paxman and Co., Ltd., we recently paid a short visit to the company's works at Colchester. The firm was established there in 1865 and started the production of agricultural machinery, boilers for locomotives and portable steam engines. In 1876 the firm moved to the present site of the Standard Works where it has continued to construct and develop its boiler plant and where since 1914 the production of oil engines has advanced from the early horizontal models to the series of Mark RPH, YH engines of to-day.

The main object of our visit was to view the Packaged "K" type water-tube boiler which the company has added to its production range and which is to be manufactured under a licence acquired from the Erie City Ironworks, Pennsylvania, U.S.A. However, the opportunity was taken to inspect the old works and its extensions and generally to see work in progress and boilers operating under working conditions. These boilers are located in the works' boiler-houses to supply steam or water for space heating, and with regard to the latter it was of interest to note the application of various methods to effect economy in fuel by reducing heat losses. Buildings have been extensively insulated and a system of air locks adopted, including electrically-operated steel roller shutter doors at the main entrances, resulting in worthwhile savings in fuel. In one boiler-house a battery of three oil-fired, all-welded steel sectional boilers was installed, the boilers supplying pump-circulated, low-pressure hot water for space heating and operating under automatic conditions with over-riding control from the shops. Good natural draught conditions exist and an efficiency of 80 per cent is claimed for the installation.

Developments have taken place in the construction technique for the "Economic" boilers which are produced as double or treble-pass units and are suitable for firing by solid, liquid or gas fuel. An all-welded design has been evolved and we were able to observe one of the new units operating in the works' boiler-house. The boiler, which was being steamed for space heating purposes, supplies saturated steam at 75 lb per square inch to a ring main and is fitted with Peabody fuel burners. This treble-pass unit has a diameter of 9ft, a length of 14ft, a shell ¾in thick, a heating surface of 2000 square feet, and is equipped with an induced draught fan. The working pressure is 100 lb per square inch, the hammer test pressure is 135 lb per square inch and the final test pressure 210 lb per square inch, and the boiler is at present being used for experimental work concerning the size and pitch of the tubing. In the design of the boiler is incorporated the new inserted flat-end construction and the boiler shell complete with end plates is stress relieved in an automatically controlled gas-fired annealing furnace.



Capacity in lb/hr	...	2500	...	17,000
Dimension A	...	6ft 1¼in	...	8ft 8in
B	...	10ft 0in	...	16ft 7in
C	...	17ft 4in	...	25ft 9in
D	...	14ft 2in	...	21ft 1in
E	...	12ft 4in	...	15ft 0in
F	...	8ft 2in	...	10ft 0in
Inside dia. G	...	12in	...	32in

Outline of the "K" boilers

Mention has already been made of the "K" design of boiler and at the company's Britannia Works one of these boilers was observed in

operation. The "Keystone" water-tube unit, of American design, is a two-drum boiler which is available in ten standard sizes, having capacities ranging from 2500 lb to 17,000 lb of steam per hour from and at 212 deg. Fah., the respective heating surfaces being 357 square feet and 2500 square feet. There are two pressure ranges, namely, up to 200 lb per square inch and from 200 lb to 400 lb per square inch. Each boiler in the range is self-contained so that it can be installed as a complete unit, four lugs being provided for lifting purposes. The boiler base is designed for floor mounting and for giving a distributed load and the floor may be any level fireproof surface which is capable of bearing a total distributed load which amounts to 10 tons for the smallest unit and increases to 26½ tons for the largest.

Our line drawing gives an outline of the boiler and the accompanying table records the main dimensions, which are approximate, of the smallest and largest units.

The steam and water drums have inspection manholes and are of all-welded construction, while the steam drum, which has the usual safety, feed, main steam and blow-off valves and the continuous blow-down connections, also has an inclined, inverted trough-shaped steam dryer baffle. These boilers are of integral furnace construction, and the tubes, of 2in outside diameter, form a continuous water wall, there being a suitable filling in the spaces between them. Convection tubes of the same diameter are placed behind the furnace tubes and except in the two smallest units of the range the tubes are displaced on either side of the centre line. Our illustration shows a completely tubed boiler.

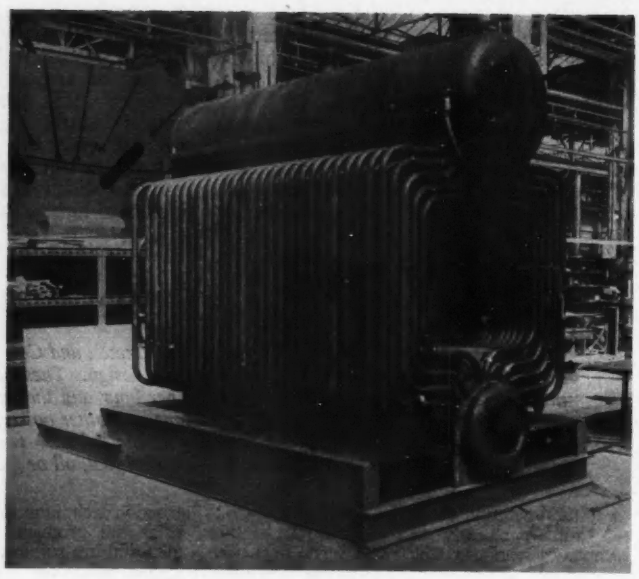
Firebrick tile and block insulation which is securely fastened in position effectively insulates the boiler walls and an airtight casing is formed around the boiler by the steel casing panels which are sealed and bolted together. After leaving the water-cooled combustion chamber the gases are forced by a system of baffles to return to the boiler front along the upper section of the convection tubes, after which they pass along in contact with the lower level of the convection tubes to the waste gas outlet. The course followed by the gases ensures adequate scrubbing action and a constant flue gas velocity is provided by arranging the heat absorbing zones with flow areas proportional to decreasing gas temperature and volume.

The example of the "K" boiler which was on view was being operated as a test unit, in association with various items of ancillary equipment, for the purpose of obtaining performance data, and for that reason was not a standard production model. However, normal equipment includes a fully automatic oil burner, which is based on the rotary cup principle and able to operate with fuels up to 3500 seconds Redwood, provided that adequate heating arrangements are supplied for dealing with the high-viscosity oil. The method adopted for lighting up is a gas jet enveloped in an oil spray ignited electrically and incorporating an automatic device which limits the admission of gas to the ignition period. Town gas can also be used for firing or a combination burner for oil or gas can be fitted. A valve actuated by steam pressure controls the amount of fuel to that required to maintain a steady head of steam, irrespective of boiler output. An automatic feed water supply regulator controlling an electrically driven turbo feed pump maintains the correct water level, and safety devices give an audible warning of low water and shut down the oil burner in the event of a drop in water level or a failure of the feed pump or the flame.

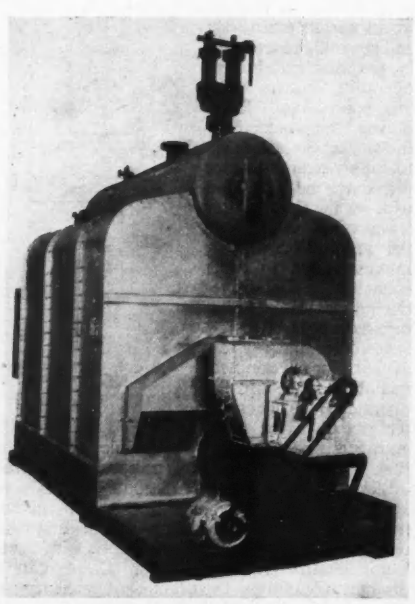
A forced draught fan is mounted on the main boiler casing and delivers air to a plenum chamber surrounding the oil burner, while an induced draught fan is fitted at the back of the boiler. To ensure that a balanced pressure is always maintained in the furnace cross-connected controls link the two fans. The second photograph which we reproduce shows the back of the boiler on test; it is a unit having a capacity of 8500 lb per hour.

A tour of the works revealed the large amount of fabrication, which was being undertaken for a number of the firm's products, and also the extensive amount of welding equipment installed. Submerged arc welding machines were dealing with boiler furnaces and, in separate bays, welding of jig-mounted fabricated crankcases and bedplates for oil engines was in progress. The aluminium alloy parts of certain lightweight engines are fabricated by welding, light-gauge material being welded by the Argonarc system and heavier-gauge parts by the Aircomatic system. Certain parts are cut out of the solid by a 56in profile gas cutting machine, which can deal with material 36in thick. A number of the company's well-known rotary vacuum filters were seen in course of construction, as were various examples of "Economic" and "Ultranomic" boilers. The 750-ton hydraulic press and its associated oil-fired furnace was observed, making boiler end plates; also seen were boiler flue rings being formed by spinning after being heated by gas. For bending boiler tubes a hydraulically operated machine, having a mandrel with a ball end attached to it, which ensured a smooth bore, was being used.

Another new boiler in which the company is interested is the "V.L." two-drum water-tube boiler, also designed by the Erie City Iron Works. These units can be fired by solid fuel, oil or gas; those having outputs up to 17,000 lb per hour can be works erected and so effect a saving in installation costs. The fuel is burnt in a combustion zone, which is formed by close-pitched tubes connected at the top to the steam drum and expanded, at the bottom, into large square section headers. Most of the heat is absorbed in the convection zone. Both drums are of all-welded design, and in the steam drum deflector plates are fitted for the whole length of the water wall, separating the discharge from the inner riser tubes and the flow to the outer downcomers. There is one downcomer for each pair of riser tubes and between the two rows of tubes is a refractory which increases the rate of flow through the downcomer tubes by keeping them cool. The latter tubes are also insulated from the steel panels which form the airtight and weatherproof outer casing. The lower drum, which is shorter than the upper drum by the length of the combustion chamber, is located at the rear of the boiler and connected to the steam drum by further tubes which form the convection zone. Baffles in the zone ensure that the gases flowing through it scrub the maximum area of tube surface before reaching the outlet. Ample grate area is provided for normal methods of mechanical stoker firing. The normal production sizes of boiler range from 6600 lb to 20,000 lb per hour from and at 212 deg. Fah. and the main dimensions of the two units mentioned are overall length 18ft 6in and 25ft 6in repectively, overall height 11ft and 14ft, and overall width 8ft 3in and 9ft 9in.



A fully tubed "K" boiler



Back of the "K" boiler showing the induction fan

An Emulsion Lubricant

THE production of a new diesel engine cylinder oil, which is claimed to reduce effectively cylinder wear in large marine oil engines burning heavy fuel oil, is announced by the Shell Petroleum Company, Ltd. Field trials began towards the end of 1953 and the oil is now in use in about 275 ships, and it is claimed that the wear reduction obtained is of the order of 70 per cent. The problem of high cylinder wear, particularly in two-stroke engines, is mainly associated with the use of boiler oil, and cylinder liners which formerly had a life of eight to ten years now only last two and a half to three years. It was considered that the principal cause was the highly acidic combustion products from heavy fuels, which set up corrosive wear. Heavy-duty oils containing alkaline additives, although effective in combating wear in small diesel engines, were found to lack sufficient neutralising ability so that a new lubricant was developed which is a stable water-in-oil emulsion, the water phase carrying the acid-neutralising additive. The new product is known as Shell Alexia Oil A.

Sixty-Four-Seater Bus in Service

THE prototype "Routemaster" sixty-four-seat double-deck bus, developed by London Transport engineers and built by A.E.C., Ltd., as an eventual replacement for trolley vehicles, started running on Route 2 (Golders Green–Crystal Palace) this week. The vehicle was exhibited at the last Commercial Motor Transport Exhibition and described in detail on September 24, 1954, pages 415–417. Since then the first vehicle, "R.M.1," has been tested both at the M.I.R.A. Proving Ground and at the Fighting Vehicle Proving Ground, Chobham, Surrey, over 6000 miles being run at the latter. A second bus will soon go into service, and two further preproduction models are to be built.

Non-Destructive Test for Small Bore Pressure Hose

By D. G. MARSHALL, J. G. SMITH, and D. L. WALKER

THE manufacture of small bore pressure hose involves binding steel braid over tubing which is supported on a mandrel. Occasionally this process gives rise to an undesirable fold or crack in the lining tube.

A non-destructive method has been developed on a laboratory scale at the Research Centre of the Dunlop Rubber Company, Ltd., for detecting incipient cracks of this kind. The method involves connecting a length of hose to a vacuum system and recording the rise in pressure produced by a crack acting as an air leak past a plunger travelling along the tube. Laboratory equipment has been devised to examine 20in lengths of hose of $^{5}/_{32}$in internal diameter, although the method is believed to be capable of extension to greater lengths.

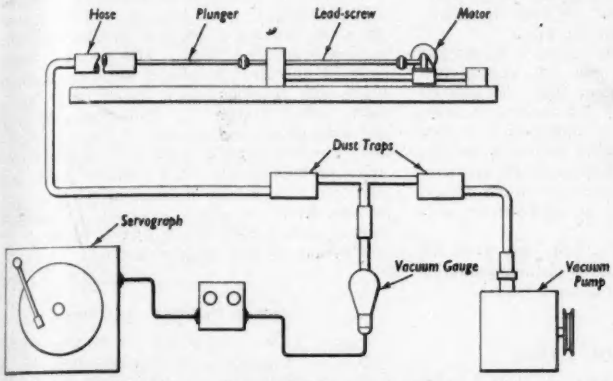


Fig. 1—Schematic diagram of apparatus for non-destructive testing of small bore pressure hose

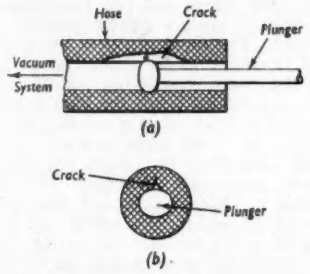


Fig. 2—Diagram showing principle of plunger

Fig. 1 is a schematic diagram of the entire apparatus.

The plunger, Fig. 2(*a*), serves the dual purpose of opening incipient cracks and of sealing the vacuum system until it is by-passed by a crack. An elliptical section was chosen for the plunger so that a crack along the minor axis of the ellipse will be opened, Fig. 2(*b*). A traverse (Fig. 1) is used which rotates the elliptical plunger and moves it into and out of the tube. The plunger is half the length of a tube which is investigated from both ends. The rotor has a speed of rotation of 75 r.p.m. and a pitch of 0·032in, although in practical applications much higher speeds would be possible.

A rotary pump producing pressures of the order of 10^{-2}mm of mercury is sufficient for this test. Pressures are recorded with the Pirani gauge head (Edwards G.4), and the circuit illustrated in Fig. 3. The variable resistance enables the servograph deflection to be set at a convenient value when the tube is sealed.

Fig. 4(*a*) shows a record of a length of hose with a number of cracks running along it. Fig. 4(*b*) shows a Servograph record of an observation on a length of hose free from cracks. The gradual diminution of pressure indicated on Fig. 4(*b*) results from the tube degassing during the experiment, but cannot in any way be confused with the effects of leaks.

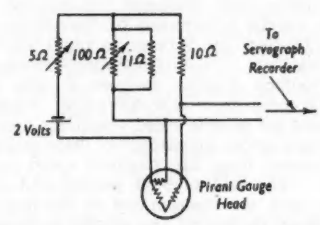


Fig. 3—Recording circuit using Pirani gauge head

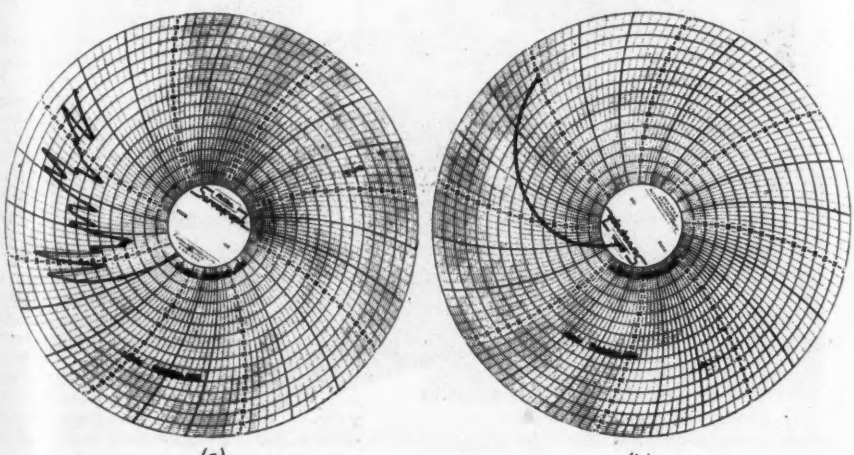
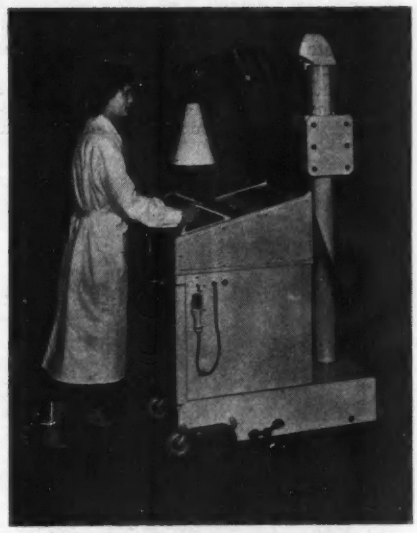


Fig. 4—Servograph record of hose with cracks (*a*) and of sound hose (*b*)

Mobile Diagnostic X-ray Equipment

THE accompanying illustration shows a new mobile diagnostic X-ray set, which is specially designed for the rapid radiography of non-ambulant cases. It is made by Newton Victor, Ltd., an associate of Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester. Two versions are available. One, known as the 100/90 set, is fitted with a single-focus rotating anode tube and has an output of 100mA at 90kVp ; the other, known as the 60/90, is fitted with a single-focus stationary anode tube and has an output of 60mA at 90kVp.

Both models have identical operating characteristics, with provision for independent selection of the current and voltage required to ensure a fully exposed film of suitable diagnostic value of any part of the body. The main items of electrical equipment, consisting of an oil-immersed h.t. transformer (for the anode supply) and a tube filament heating transformer are contained in the sheet steel compartment below the control desk, with shockproof cables to the X-ray tube plugged into receptacles mounted on the transformer cover plates. The control panel contains all the operational instruments, including a kVp selector in steps of 5kVp and mA selector with a coloured signal dial correlating with the kVp selector dial.



Mobile diagnostic X-ray equipment. There are two versions: one has an output of 100mA, and the other an output of 60mA, both at 90kVp

In both units an oil-immersed anode tube unit is supported in a gimbal ring mounting. In the case of the 100/90 set the tube is an MX245 single-focus X-ray tube having a nominal projected focal area of 1 square millimetre. The stator is automatically energised when the main switch is placed in the " on " position. A delay relay is fitted to prevent exposure being made before the rotor has reached full speed. The 60/90 set incorporates an NVD134 single-focus X-ray tube having a nominal projected focal area of 3·5 square millimetres.

As may be seen from the illustration, the tube stand is a vertical column of circular section, supported at the base in a bearing assembly providing lateral support, with smooth rotational movement. A foot brake is provided to lock the rotation at the desired position.

The tube assembly is carried on twin cross members mounted on a rectangular vertical carriage, which is counterweighted and suspended by twin steel flexible cables. A shroud covers the counterweight pulley.

The tube carriage is arranged to provide the following adjustments : vertically from 11in firing vertically upwards to 72in firing downwards, focus to floor ; maximum distance, tube focus from tube column, 26in ; tube angulation round tube axis, 15 deg. each side of normal ; angulation round cross member axis, 360 deg.; angulation round tube column axis, 360 deg.,

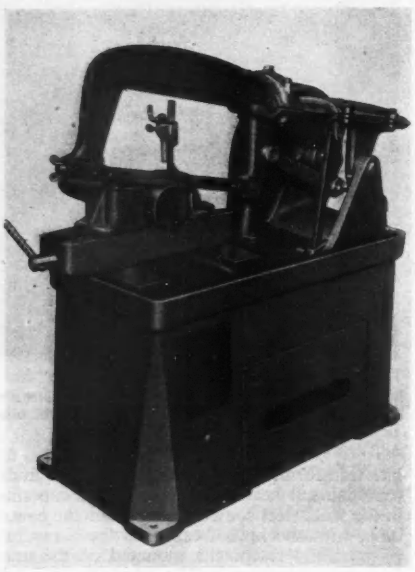
with positive location at 0, 90, 180, and 270 deg. Vertical and angulation scales are provided.

The equipment described above is mounted on a chassis of underslung cast construction with four wheels, the two at the control desk end being castors for steering. There is a foot brake to anchor positively two of the wheels. A cassette box to hold six 17in by 14in loaded casettes is mounted at the front of the transformer housing and below the control panel.

Medium-Duty Hacksawing Machine

AN improved design of the medium-duty "Rapidor-Manchester Major" hacksawing machine recently introduced by Edward G. Herbert, Ltd., Atlas Works, Manchester, 19, is illustrated below. The new machine has a heavy saw frame of rigid design which can take 14in blades and is guided by two square steel bars. An adjustable oil dashpot gives automatic relief to the blade on the return stroke, and a limit switch automatically stops the machine at the end of each cut.

The machine is driven through vee belts by a ½ h.p. motor controlled by a push-button-operated starter with undervoltage and overload release protection. Two speeds which are available give 120 and sixty-five strokes a minute. A chain-driven suds pump can be mounted inside the box base of the machine if required.

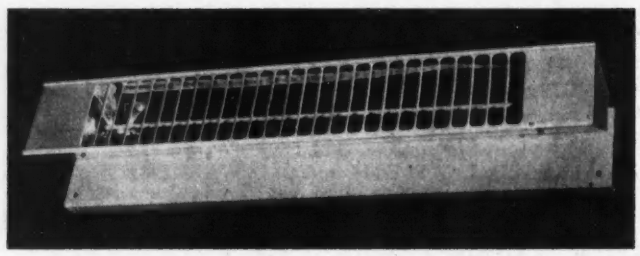


Improved medium-duty hacksawing machine to take 14in blades and having two speeds of 120 and 65 strokes per minute

A standard 6in by 6in capacity swivel vice supplied with the machine can be replaced by a split vice of 4½in by 4½in capacity. With this vice the saw blade reciprocates through slots in the centre of both jaws, so that both the bar stock and the blank are held rigidly throughout the cutting operation. The maker states that with this vice bar stock can be sawn to the last inch and short-end wastage can be reduced to a minimum.

Electric Radiant Heater

AN electric fire has been introduced by Hanovia (Lamps Division of Engelhard Industries, Ltd.), Bath Road, Slough, Bucks, in which the filament is enclosed within a silica tube of about ¼in diameter. The "Radsil" heater can be mounted in any attitude so long as the element is horizontal and, since the sleeve is moisture-proof, it is suitable for use in steamy atmospheres or out of doors. The heating coils, 250W, 500W or 750W, fit loosely within the tube and are easily changed, an economic advantage over wires wound on ceramic cores. The avoidance of air cooling of the conductor is claimed to allow a higher working temperature and an increase in efficiency, a suitable nickel-chrome alloy being used for the wire.



The filament of this radiant heater is enclosed in a silica tube

A reflector of chromium-plated brass directs the heat into a beam roughly 3ft deep at 10ft from the unit; the existing 26in unit will be supplemented by 48in and 72in models consuming up to 3kW. The two halves of the grille seen in the illustration slide outwards to give access to the terminals at the ends of the element. The heater is pivoted on its base, which always remains cool, and has mounting holes at each corner.

200/230V and 230/250V units are available and it is intended to produce elements suitable for use in the vertical attitude.

10½in Centre Lathe

A RECENT addition to the series "85" lathes made by Woodhouse and Mitchell, Ltd., Wakefield Road, Brighouse, Yorks, is the 10½in lathe, illustrated below. This machine, which can be supplied with beds to admit up to 72in or 96in between centres, swings work up to 21in diameter over the bed, 12½in over the cross slide or 32in by 9in deep in the gap.

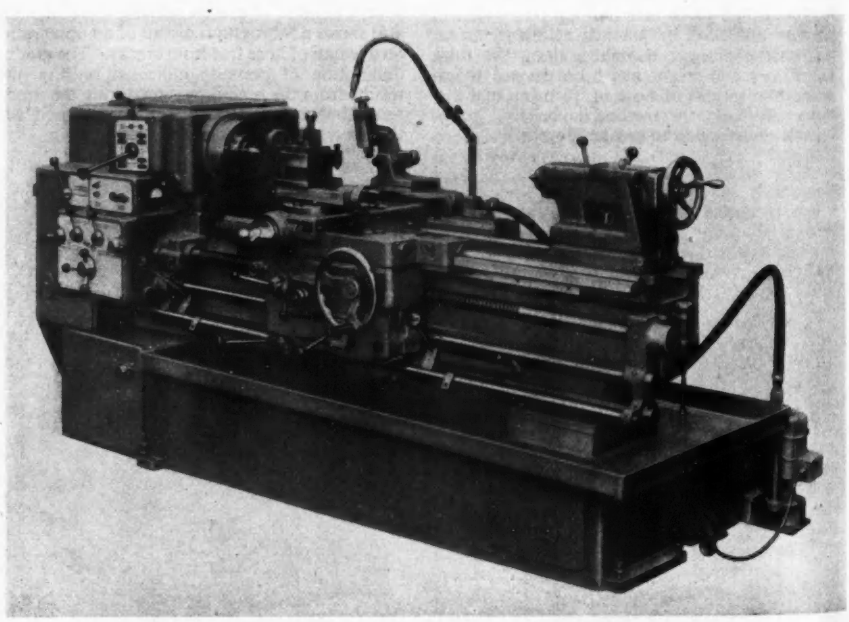
The box section, cast iron bed is carried by a fabricated steel base, within which the 10 h.p. main motor and switchgear are enclosed. The main spindle is mounted in heavy-duty taper roller bearings and is bored to admit up to 2½in diameter bar. It is driven through sliding gears and toothed clutches designed to give twelve spindle speeds from 14 to 630 r.p.m. Two levers are used for spindle speed selection; one lever for selecting four ranges each of three speeds, and the second lever the required speed in each range. The feed take-off gearing and reverse mechanism are incorporated in the headstock. The main control of the spindle is through a multi-plate clutch actuated by duplicated levers on the headstock and the carriage apron. A spindle brake is also fitted.

The feed gearbox provides thirty-nine different English pitches from 2 to 28 T.P.I., and by transposing gears additional ranges of metric, module, diametral and other pitches can be obtained. A "coarse-fine" control on the carriage apron doubles the feed range so that feed rates from 0·0037in to 0·103in per revolution are available.

The carriage is guided on the bed on a front vee, a flat bearing at the rear and an additional bearing below its bridge. The apron is totally enclosed and incorporates a lubrication system which also provides oil to the carriage bearing ways. The carriage cross slide has a travel of just over 14in, and control of the sliding and surfacing motions is effected by a large-diameter lever-operated clutch and a selection lever. This selection lever is also used to select the coarse or fine feed for either motion. A separate coolant tank with a motor-driven pump at the rear of the lathe is castor mounted.

Steam Safety Valves

SAFETY valves manufactured by the Crosby Valve and Engineering Company, Ltd., Ealing Road, Wembley, have recently been tested at a Central Electricity Authority power station. The discharge is regarded as the product of nozzle area, lifting pressure, and a coefficient; the values of this coefficient have been set by Lloyd's Register of Shipping at 30, the maximum allowed for marine boiler installations, and by the Associated Offices Technical Committee at 38 for boilers fitted with the minimum of two-drum safety valves and one superheater safety valve and 42 where a greater number of valves are fitted. This range of valves has nozzle areas up to 15 square inches; both nozzle and disc have flat seats, simplifying resurfacing. The nozzle is extended below the joint flange facing the boiler so that only the stainless steel nozzle and seat are under pressure when the valve is closed; the nozzle fits loosely into the body to prevent asymmetric distortion of the body affecting it. Both nozzle and seat guide have threaded adjusting rings, which can be set to bring the closing pressure near to that of opening with positive operation in both directions.

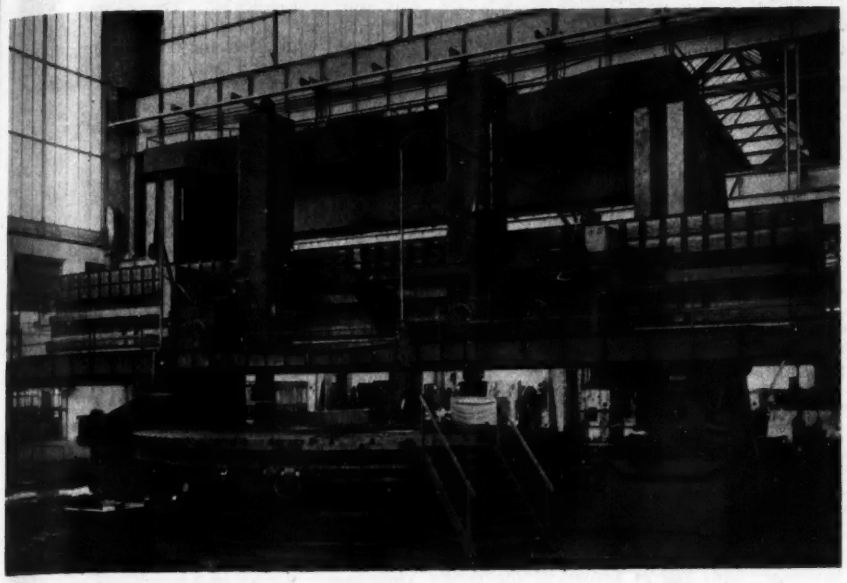


Centre lathe designed to swing work up to 21in diameter over the bed and 12½in over the cross slide. This lathe is made in two sizes to admit work up to 72in or 96in between centres

Continental Engineering News

Large Vertical Boring Mill

The accompanying illustration shows a large double-column vertical boring mill recently completed by Schiess Aktiengesellschaft, Hansa-Allee 245, Düsseldorf, German Federal Republic. This machine, the Model 26 GK 900/1200, of



50ft capacity boring mill, weighing nearly 500 tons, during assembly at maker's works

a total weight of nearly 500 tons, has an inner table measuring 14ft 9in in diameter, surrounded by an outer table of 29ft 6in diameter. It is designed to handle work up to 40ft in diameter with the columns in the normal position, but when the columns have been moved to the rear on their sliding bases, the maximum turning capacity is increased to 50ft. Workpieces up to 11ft 6in high can be accommodated. Two toolheads are fitted on the cross rail for turning, and they have a vertical travel of 6ft 7in. In addition, there is a special milling and boring head for use in conjunction with the indexing and creep motion of the table, so that milling and boring operations can be carried out without the need to set up the workpiece again on another machine.

Both inner and outer tables are assembled from sections. The outer ring table runs on an outer flat and an inner vee-shaped sliding surface, while the inner table has a vee-shaped sliding surface and a centre pivot, with arrangements to balance the thrust due to the weight of the workpiece. The inner and outer tables can carry loads of up to 40 and 80 tons, respectively, and can be independently driven at infinitely variable speeds selected, in each instance, from four speed ranges. Both tables can, of course, be locked together.

For the outer table, speeds from 0·1 to 12 r.p.m. are available, while the inner table can be rotated at 0·23 to 28 r.p.m. The creep mechanism can turn the tables at a range of slow speeds from 0·0004 r.p.m. to 0·1 r.p.m.

The toolheads have twelve vertical, horizontal and angular rates of feed, from 0·0039in to 0·5118in per revolution ; these feeds are infinitely variable in a ratio of 1 : 1·5 up or down at each step. A taper turning attachment is fitted to each slide, and the right-hand head has, in addition, an electrically operated copying device for use with a template. Feed drives to the heads are self-synchronising. Dial indicators are provided to show the horizontal and vertical movement of the toolheads.

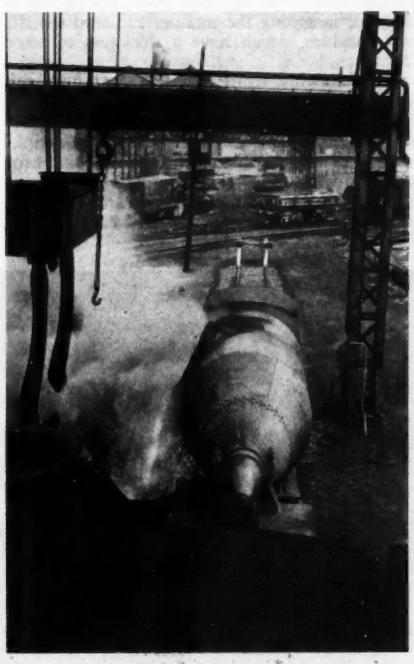
The milling and boring head is equipped with a quill which can be extended by 2ft 2in. Eighteen speeds of from 9·5 to 475 r.p.m. are available, with horizontal milling feeds of 0·295in to 1ft 3in, and vertical milling feeds of 0·187in to 9·291in. There are eight boring feeds, ranging from 0·0079in to 0·1968in per revolution.

A motor generator set and the main motors and drives are arranged in a pit behind the machine. All controls are electric. Of particular interest is the movement of the two columns which is by electrically driven screw spindles. The action of the two spindles is synchronised by electric means, without any mechanical connection.

The agent in this country is Burton, Griffiths and Co., Ltd., Mackadown Lane, Kitts Green, Birmingham, 33.

Transport of Liquid Steel by Rail

The transport of molten steel is being undertaken by the Société Nationale des Chemins de fer Français, the first instance of this being the delivery on November 5th of last year of a charge of liquid steel from Trith-St.-Léger to Lourches, a distance of 15km. This development goes back to 1954, when a study was begun by the S.N.C.F. at the request of Société Usinor, whose works at Valenciennes had an excess melting capacity, which, it appeared, could be absorbed by another Usinor works at Denain, whose capacity was insufficient to keep the hot rolling mill fully loaded.



Transporter wagon discharging 70 tonnes of molten steel after carrying it a distance of 15km. During the journey the temperature of the steel dropped from 1400 deg. to 1290 deg. Cent.

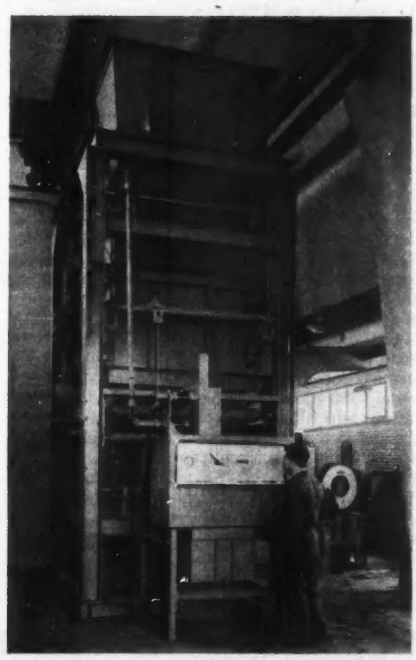
Our illustration shows the transporter employed. Basically, it consists of a horizontal cylindrical container, terminating at each end in a truncated cone, and supported on four double-axle bogies. Internally the container is lined with refractory brickwork, and is hermetically closed during its journey. The wagon has an empty weight of 105 tonnes and is capable of carrying a liquid charge of 70 tonnes.

During the journey of November 5th the temperature of the charge dropped from an initial 1400 deg. to 1290 deg. Cent. on discharge three hours later. The outer walls of the container did not exceed 110 deg. Cent.

About 400 similar wagons are in use in the United States, where they are employed almost exclusively within the works themselves. In Great Britain also a few such wagons have been put into service. This is stated to be the first time, however, that a European railway has undertaken the transport of molten steel. If subsequent tests prove satisfactory, it is intended to run a daily service of special trains, comprising one to three molten steel wagons, as well as trucks for the transport of hot ingots. The latter kind of transport is at present being undertaken by attaching the trucks to ordinary goods trains.

Large Automatic Weighing Plant

What is claimed to be the largest automatic weighing machine for raw sugar in the world is being constructed by the firm of Servo-Balans N.V., The Hague, Holland. The machine,

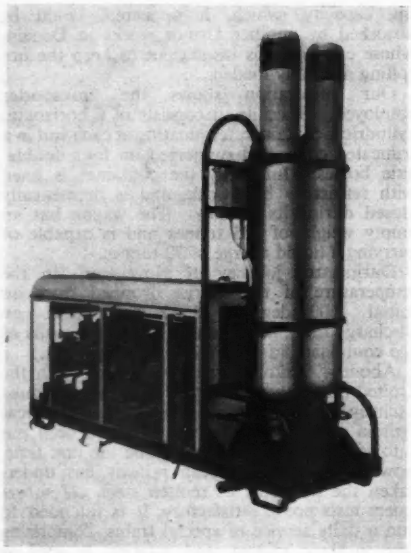


300 tons per hour automatic weighing plant for sugar

which is intended for a sugar factory in Australia, will be 54ft high and will have a capacity of 750 tons per hour. The previous biggest machine had a capacity of 300 tons per hour and was installed at the factory of Tate and Lyle, Ltd., London (see accompanying illustration). Servo-Balans N.V. is associated with W. and T. Avery, Ltd., Birmingham, which handles its interests in the United Kingdom and the Dominions.

Compressed Air Plant

Among the products of the firm of Compresseurs Luchard, 137–161, Avenue Georges Clemenceau, Nanterre, is the electrically driven compressor plant, shown in the illustration overleaf. It has a hourly output of 7 cubic metres at 150 kg per square centimetre, and is laid out for fully automatic operation, the pressure in the compressed air bottles being



Electrically-driven compressor having an output of 7 cubic metres per hour at 150 kg per square centimetre. Delivery pressure is variable from 5 kg to 150 kg per square centimetre

maintained at a preset value. This plant, called the "HE.7.A.SD," is specially designed for convection cooling. It can be arranged for connection to two or more compound air containers of 46 litres capacity, which can be charged at pressures up to 150 kg per square centimetre. All the usual safety devices and controls are incorporated in this plant, which also possesses a reduction valve covering a range of delivery pressures of 5 kg to 150 kg per square centimetres. The air delivered is stated to be dry and free from oil. As may be seen from the illustration, the plant is roofed over for out-of-doors installation.

German Standards Publications

The German Standards Committee (Deutscher Normen Ausschuss) has now issued its 1956 list of standard specifications,[1] which contains the numbers, titles and publication dates of the 9700 German standards and proposed standards. The list is complete to the end of October, 1955, and compared with the previous issue (1954), contains 900 additional standards and 700 additional proposed standards. Approximately 350 standards have been revised. Specifications which have been withdrawn are specially marked in the list, as are those for which translations are available, such translation being mainly into English, French, Spanish and Portuguese. As before, the text is arranged according to the Universal Decimal Classification, and an index to numbers, as well as a detailed subject index, has been provided.

The Committee has also issued Part A of Din-Manual No. 6: "Tool Standards, High-Speed Steel and Tool Steel Cutting Tools."[2] This handbook refers to spiral drills, countersinks, reamers, milling cutters, lathe cutting tools, chasers, taps and dies, and gear tooth cutters and hobs. It includes all the 126 basic tool standards. If one compares the present edition with the previous edition of Manual No. 6, which appeared in 1926, it is at once apparent that tool standardisation has made great strides during the intervening decades. The majority of the standards are new issues, many being published during the last few months.

A further publication by DNA is its Din-Manual No. 21 on "Plastics."[3] This is the first time that a collection of existing German standards in this field has been published. *Inter alia*, the manual contains the most recent type-lists and revised electrical testing methods. It is subdivided into four main parts, comprising the new Universal-Decimal Classification of macromolecular substances, lists of standards (indexed according to definitions, product groups, nomenclature, grades, special tests, and sizes), tests and tooling, and a collection of 117 standards printed *in extenso*.

REFERENCES

[1] Berlin, W.15, and Cologne: 1955. Beuth Vertrieb G.m.b.H., Berlin, W.15, Uhlandstrasse 175. Price DM. 9·60.
[2] As above. Price DM. 15.
[3] As above. Price DM. 22.
All German standards publications are obtainable through the British Standards Institution, 2, Park Street, London, W.1 (Tel., MAYfair 9000).

Rhine Bridge at Cologne

After consideration of the designs submitted in a competition for the proposed bridge over the Rhine in continuation of the Gothenring avenue, the Cologne municipality decided on November 24th last in favour of the design "counterpoint" submitted by Gutehoffnungshütte Sterkrade A.G. Our accompanying illustration shows a model of the bridge, as seen from downstream from the right bank of the river. Sited some 900m to the south of the existing Deutzer bridge, the new design will be carried out as a single-pylon bridge, with a biggest span of 302m, between the pylon and the supports on the island near the left bank. This will leave a shipping fairway of 282m between the pylon and the embankment. The triangular shape of the pylon, which rises to 64m above the bridge deck, allows the roadway to be carried through in its full width of 29·5m. Of this, the actual carriageways occupy 19m, the remainder to be used for the sidewalks and cycle paths.

The total length of the bridge will be approximately 700m. About 8200 tons of steel are to be used, including the amount required for the twelve cables, which have a thickness of some 25cm.

The following firms will be associated with the execution of the work:—Gutehoffnungshütte Sterkrade A.G., Butzer Köln, Hochtief Köln, and Strabag Köln. The consulting architect is Dipl.-Ing. G. Lohmer, Cologne, and the consultant for traffic questions Dipl.-Ing. G. Hinterleitner, Cologne/Stuttgart. Construction is scheduled to be completed in the summer of 1958.

Leipzig Spring Fair

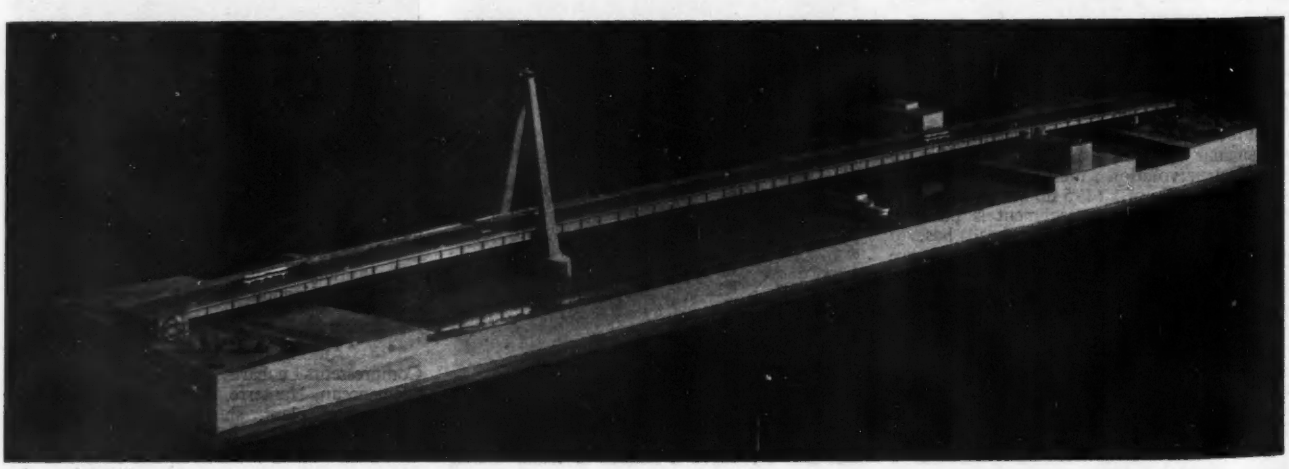
A large proportion of the Leipzig Spring Fair, which is to be held from February 26th to March 8th, will be occupied by displays of machine tools. Among the chief exhibits from the German Democratic Republic will be lathes, while other exhibits will include milling and planing machines, boring mills, special-purpose machines, presses and complete transfer lines, as well as accessories. The German Federal Republic will show a number of machine tools equipped with electronic controls, pressing and forging machinery, and special-purpose plant. As in previous years, the display from the Soviet Union will be very comprehensive, and will include the application of automation to production as well as to measuring and testing. Other countries whose machine tool industries will take part include Czechoslovakia, Poland, Hungary, Bulgaria and Rumania and China.

International Congress on Industrial Electron Microscopy

We learn that the theme of this year's congress held by the Liége Polytechnic Association (A.I.Lg) in conjunction with the International Liége Fair in May, will be the industrial application of electron microscopy. Organisation of the congress has been put in the charge of Professor P. Coheur, director of the C.N.R.M., and his assistant, Monsieur L. Habraken, who is president of the Belgian association for electron microscopy. Both are members of the A.I.Lg and have specialised in the application of electron microscopy to metallurgy and chemistry. Among the topics which will be dealt with are the evolution of instruments and methods, the importance of electron microscopy to the metallography of ferrous and non-ferrous metals, as well as to the study of the solid state, and some special chemical applications. Among the foreign scientists taking part will be research workers from Germany, France and England. There will be a scientific exhibition within the framework of the Liége Fair, and a visit to the Liége section of the National Centre for Metallurgical Research (C.N.R.M.). Those interested should apply to Secrétariat Général de l'Association des Ingénieurs sortis de l'Ecole de Liége (A.I.Lg), 22, Rue Forgeur, Liége (Belgium).

Professor Carl Ramsauer

We learned with regret of the death in Berlin of the professor emeritus and honorary senator of Berlin-Charlottenburg Technical University, Dr. Carl Ramsauer, in his seventy-seventh year. Following his academic activity at Heidelberg and Danzig, Dr. Ramsauer, in 1933, became head of the newly-founded research institute of Allgemeine Electricitaetsgesellschaft, and a member of the Board of A.E.G., which he continued to serve in an advisory capacity after his retirement. For his achievements in many fields of physics, he was decorated by the Federal President with the Grand Cross of the German Pour le Merite Order.



Model of "Counterpoint" single-pylon design for Rhine bridge at Cologne

Industrial and Labour Notes

Budget Representations

The Engineering Industries Association has sent to the Chancellor of the Exchequer some proposals which, it is suggested, should be considered in the framing of this year's budgetary policy. These proposals urge that there should be "no more controls," a progressive reduction of all subsidies, encouragement of new savings, and reduction and restraint in public expenditure undertaken by the Government, the nationalised industries and municipal authorities. The Association adds, however, that this restraint must have proper discriminatory regard to the essential increasing demands by industry for coal and services such as atomic power, electricity, fast rail freight transport, and the road programme.

At the end of the memorandum setting out its proposals, the Engineering Industries Association records "its alarm in regard to the gap in knowledge and opinion which seems to become ever widening as between the three elements in the community in whose hands rests the economic future of the nation." These "three elements" are the Government, the employer and the employed. The memorandum says that the machinery for consultation between these three elements on the structure of national policy, far beyond the levels concerned in political partisanship, are almost non-existent. In consequence, the Association argues, "we have legislation devised by governments which is based, in the eyes of employers and employed, on grave psychological miscalculations and which misfires in its economic purpose." The Association asserts that there is the widest possible divergence of view as between employer and employed on major matters of economic policy, and the relation between wages, costs and profits, which renders stillborn any long-term plan to kill inflation by traditional methods. The Association feels that there is need for an "industrial and economic council" which could provide a meeting ground where the Government, representatives of industry and representatives of the employed could deliberate upon such matters as budgetary policy. In this way, it is suggested, successive Chancellors could utilise opinions and representations of the two great industrial parties after there had been an opportunity to reconcile their respective views on a mutual basis.

Steel Demand

Some observations on the steel situation are made by Mr. R. F. Summers, chairman of John Summers and Sons, Ltd., in a statement which has been circulated with the company's annual report. He says that, in spite of a substantial increase in the total output, it has been impossible in many cases for the British steel industry to meet the demands put upon it, with the result that considerable tonnages of steel have had to be imported from other countries. But, the statement adds, there is nothing new in this; this country has been, for many years, an importer of steel—chiefly in the semi-finished form—while at the same time the export of steel products has played an important part in the nation's economy. Mr. Summers thinks it would be unfortunate if exports were further curtailed, as this might well endanger the industry's future position in its traditional foreign markets. He says that everything seems to point to a further expansion of demand, and that the question of finding ways and means of satisfying it has been occupying the minds of the leaders of the industry.

Much has been said and written, Mr. Summers continues, about the need for a higher production of steel in this country, but in many cases the problems involved are passed over too lightly. The industry has been blamed in some quarters for not expanding production more quickly, but Mr. Summers suggests that the critics overlook the time required to carry out a large scheme of development. They forget, he comments, that, with industry in general substantially at full production, there is a limit to the amount which it is possible to do in any given time. In the past, the statement goes on, the steel trade has always been prepared to approach the question of expansion in a realistic and energetic manner, as is borne out by the fact that steel production in this country has risen from just under 12,000,000 tons in 1945 to nearly 20,000,000 tons in 1955. Mr. Summers says he sees no reason why that policy should not continue. He emphasises, however, that before embarking on large-scale schemes we should be quite certain that the necessary coking slack will be forthcoming, and that foreign ore, and the ships with which to transport it, will be available.

Industrial Production

Last week, the Treasury announced that the index number of industrial production (1948 = 100) had been estimated provisionally at 146 for all industries in November, 1955, compared with 144 in October. Figures for the corresponding months of 1954 were 140 in November and 139 in October. The Treasury shows in its analysis that the index for the manufacturing industries only last November was 150, compared with 144 a year earlier, for mining and quarrying it was 119, compared with 118, and for gas, electricity and water supply 173, compared with 161. On the basis of the information so far received, the Treasury expects that the index for all industries in December last will be 134 or 135, against 131 in December, 1954. On this basis the index averaged 136 throughout last year, compared with 130 in 1954.

Iron and Steel Holding and Realisation Agency

The Iron and Steel Holding and Realisation Agency has published its second annual report, which surveys its operations in the year ended September 30, 1955. The Agency was set up under the terms of the Iron and Steel Act, 1953, and securities of seventy-one iron and steel companies became directly vested in it on July 13, 1953. It was the duty of the Agency to secure the return to private ownership of the undertakings belonging to those companies and their subsidiaries. By the end of the year reviewed in the present report, twenty-eight companies had ceased to be subsidiaries of the Agency. The report says that in terms of employment, of steel production and sales of products, these twenty-eight companies represented about three-fifths of the Agency's inheritance. During the first part of the year under review, the report comments, market conditions were generally favourable to the Agency's disposal operations. In the spring of last year, however, market conditions changed. Among the factors which made the climate for public offers less favourable, it is added, were the increase in bank rate, the general air of uncertainty resulting from the newspaper strike, the announcement of the General Election, and the railway strike. The report records that the total cash paid to the Treasury up to September 30, 1955, amounted to £79,700,000, of which £27,900,000 in total was paid by the Treasury into the Exchequer, leaving a balance in the iron and steel realisation account of £51,800,000.

Committee on Inland Waterways

The Minister of Transport and Civil Aviation, Mr. Harold Watkinson, announced in Parliament, on February 1st, the setting up of a committee to consider the future of this country's system of inland waterways. The Minister recalled that a thorough investigation was made in 1954 by the Board of Survey appointed by the British Transport Commission, but there were indications that there was a need for further inquiry on a broader basis.

Mr. Leslie Bowes, managing director of the Pacific Steam Navigation Committee, is the chairman of the committee, the other members being Mr. John Corbett, of Peat Marwick, Mitchell and Co.; Mr. G. C. Godber, clerk of the Shropshire County Council; Mr. H. E. Hopthrow, assistant secretary of Imperial Chemical Industries, Ltd.; Mr. W. A. Muddell, chairman of the land drainage committee of the River Boards' Association; Mr. F. Ritchie, of the National Parks Commission; Mr. Michael Rowe, Q.C.; and Mr. John Wilson, general manager of the Clyde Navigation Trust. The committee has been asked to make proposals for any measures necessary to achieve: (i) the maximum economic use of the inland waterway system; (ii) the future administration of and financial arrangement for such inland waterways as cannot be maintained economically for transport purposes; and (iii) the conversion of canal sites to other purposes when this is considered desirable and practicable. In addition, the committee is required "to consider the present law relating to the closing of waterways to navigation and to make recommendations."

Coal Production

A statistical statement from the Ministry of Fuel and Power shows that the saleable output of coal in the first four weeks of this year, to January 28th, amounted to 17,641,400 tons, or about 8000 tons more than in the comparable period of last year. The increase was in the output from opencast sites, as deep-mined production in January was about 142,000 tons below that of January last year. Most of the decrease is accounted for by a bigger loss of deep-mined tonnage on account of the New Year holidays.

Colliery manpower is still a matter of considerable concern. On January 21st the number of workers on colliery books was 702,200, of whom 286,700 were face workers. On the comparable date last year the manpower total was 708,000 and of that total 290,300 were working at the face. Output per manshift, at 3·368 tons, is slightly higher than it was a year ago. Inland coal consumption in the first three weeks of this year amounted to 14,191,000 tons, or about 250,000 tons less than in the corresponding period of last year. In the first three weeks of January 382,100 tons of coal were imported, and on January 21st distributed stocks totalled 17,028,000 tons, compared with 13,214,000 tons on January 22, 1955.

Capital Expenditure

Last July, the Board of Trade initiated a regular inquiry to obtain up-to-date information about capital expenditure by private industry. About 650 companies, covering manufacturing, distribution, transport and service trades, were invited to provide particulars. The information sought includes all expenditure charged to capital account on assets for use or installation in the United Kingdom, and also particulars of past expenditure on plant and machinery, vehicles and vessels, and new building work.

Some results of the first stages of this inquiry have now been published. They show that the total expenditure by manufacturing industry in the year 1954 was £592,400,000. Last year, it is estimated, the total expenditure was 18 per cent higher, and the estimate for the current year is that total expenditure will be 17 per cent above the final figure for 1955. The Board of Trade, in presenting these results, says that the figures must be treated as provisional. A preliminary analysis of the returns of actual expenditure during each of the first three quarters of 1955 has indicated that expenditure was rising sharply during the year. In manufacturing industry, expenditure during the first quarter represented 29 per cent of the total for the nine months, the second quarter 32 per cent, and the third quarter 39 per cent. The increase in expenditure on building work was somewhat steeper than that on plant, machinery and vehicles.

International Atomic Exposition at Cleveland

BY OUR AMERICAN EDITOR

No. IV—(*Concluded from page* 181, *February 3rd*)

The first International Atomic Exposition was held at the Public Auditorium in Cleveland, Ohio, from December 10th to December 16th in conjunction with a Nuclear Engineering and Science Congress. The exhibition was organised under the sponsorship of the American Institute of Chemical Engineers and was attended by some 20,000 visitors. It presented a comprehensive picture of the current state of development in the application of atomic energy in American industry, and this article reviews certain exhibits of particular interest.

National Lead Company

DUE to its position as a supplier of a number of basic materials to many industries, and to its wide range of fabrication facilities, the National Lead Company, New York, is in a position to supply many of the needs of the new atomic energy industry, and to provide materials and equipment required in connection with the shipment, use and storage of by-products of atomic energy, such as radioactive isotopes. Among the company's products that have proved or indicated usefulness in the atomic energy field and that were displayed are lead, barite and magnetite, which are high density materials and therefore are useful in radiation shielding; zirconium, which has properties of value in cladding and certain pieces of reactor equipment; titanium, which may be used in fabricating high-strength, low-weight, corrosion-resistant apparatus; nickel, which is a valuable alloying element; cobalt, which may be irradiated to the isotope cobalt-60; bismuth, which will find use in metal slurry reactors; cadmium, which is an efficient neutron absorber and finds wide use on control rods; and finally, the reactor fuel elements themselves—uranium and thorium.

As a miner, smelter, refiner and converter of many metals and minerals, over a long span of years, the National Lead Company has built up not only physical plant but has also acquired a considerable experience. Moreover, as the contract operator of the A.E.C. Feed Materials Production Centre at Fernald, Ohio, and of A.E.C. laboratories at Winchester, Massachusetts, and Grand Junction, Colorado, the company is itself engaged in atomic energy work and is aware of the problems which are bound to confront the new industry.

Westinghouse Electric Corporation

The display of the Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, in addition to models of its 60MW nuclear power plant being built at Shippingport for the Duquesne Light Company, stressed its "Zircaloy-2" material. This low alloy of zirconium was developed by the Atomic Power Division of the company during 1952, but had remained classified until recently. In reactor technology zirconium and its alloys are attractive from the point of view of their low neutron absorption. This desirable characteristic of zirconium is offset by its low strength properties and its highly variable corrosion behaviour in the commercially pure condition. Zircaloy-2, on the other hand, has consistently good corrosion resistance in high-temperature water, improved strength properties for design, sufficient ductility for fabrication and little change in neutron absorption due to the alloy additions. The use of Zircaloy-2 in America has increased in proportion to the development of water-cooled reactors. A typical composition range is given below in weight per cent.

Tin	1·3 to 1·6
Iron	0·07 to 0·20
Chromium	0·05 to 0·16
Nickel	0·03 to 0·08
Average (Fe+Cr+Ni)	0·23 to 0·32
Nitrogen, max.	0·006

The physical properties of Zircaloy-2 are listed in the following table.

Density	0·237 lb per cubic inch (at room temperature)
Thermal expansivity	$6{\cdot}5\times10^{-6}$ per deg. Cent. (from room temperature to 350 deg. Cent.)
Modulus of elasticity	$14{\cdot}0\times10^{6}$ lb per square inch
Poisson's ratio	0·31

The tensile strength in the longitudinal direction of the alloy decreases with increasing temperature, as shown in Fig. 12. For comparison purposes the strength-temperature curve for arc-melted crystal bar zirconium is also shown. The square symbols represent the average of two tests in the hot-rolled condition. In order to evaluate the variability of the material, tensile specimens from ten ingots were tested and the standard deviation calculated. Tensile specimens taken transverse to the rolling direction differed little in strength from their longitudinal counterpart at all temperatures. The effect of cold work on the strength properties is shown in Fig. 12 by the curve passing through the open circle symbols. The curve shows the increase in tensile strength at all temperatures caused by 60 per cent cold rolling. This is close to the practical limit of cold working for Zircaloy-2; further cold rolling produces pronounced edge cracking and often results in failure during rolling. It is perhaps surprising that strength properties in the longitudinal and transverse direction do not differ by more than a few thousand pounds per square

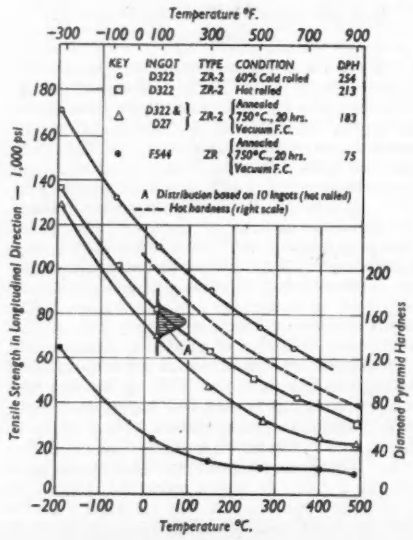

Temperature °F.
−300 −100 0 100 300 500 700 900
KEY INGOT TYPE CONDITION DPH
○ D322 ZR-2 60% Cold rolled 254
□ D322 ZR-2 Hot rolled 213
△ D322 & D27 ZR-2 Annealed 750°C., 20 hrs. Vacuum F.C. 183
● F544 ZR Annealed 750°C., 20 hrs. Vacuum F.C. 75
A Distribution based on 10 Ingots (hot rolled)
Hot hardness (right scale)
Tensile Strength in Longitudinal Direction — 1,000 psi
Diamond Pyramid Hardness
180 160 140 120 100 80 60 40 20 0
200 160 120 80 40 0
−200 −100 0 100 200 300 400 500
Temperature °C.

Fig. 12—Graph showing the effect of temperature on the strength and hardness of "Zircaloy-2" zirconium alloy

inch even after 60 per cent cold rolling. The yield strength of the alloy parallels the behaviour of the tensile strength with respect to the effects of temperature, annealing and cold work. Annealing decreases the strength properties at all temperatures as shown by the triangular symbols in the graph. Annealing was done at 750 deg. Cent. for twenty hours in vacuum.

The hardness of Zircaloy-2 was found to follow the behaviour of the tensile strength. Diamond pyramid hardness values at room temperature for the four curves in Fig. 12 are also plotted and reflect the strength level of the material tested. The values listed are based on a load of 30 kg. It should be remembered that even with a carefully prepared surface a very strong load dependence of D.P.H. values is characteristic of zirconium and its alloys.

The most important single property of Zircaloy-2 is its excellent corrosion resistance in high-temperature water, in which respect it is vastly superior to unalloyed zirconium. The corrosion of unalloyed zirconium in high-temperature water is characterised by the formation of a tightly adherent zirconium dioxide film during a more or less protracted period of exposure, after which the oxide becomes non-adherent. During the first period a quasi-cubic rate law is followed, while in the second period a linear rate law is followed. The time at which the first period is interrupted is highly variable and is shortened when small amounts of nitrogen or other impurities are present in the metal. Furthermore, the corrosion rate during the second period is very high. In the case of Zircaloy-2, however, the time at which the initial period is interrupted is highly reproducible, and is relatively insensitive to impurity content, and in the second period the corrosion product is adherent and the corrosion rate is low. These are the principal advantages of the new alloy and they become more pronounced with increasing temperature. A further advantage which is derived from the decreased sensitivity to impurity content is that Kroll process sponge zirconium can be utilised in the production of Zircaloy-2.

New York University

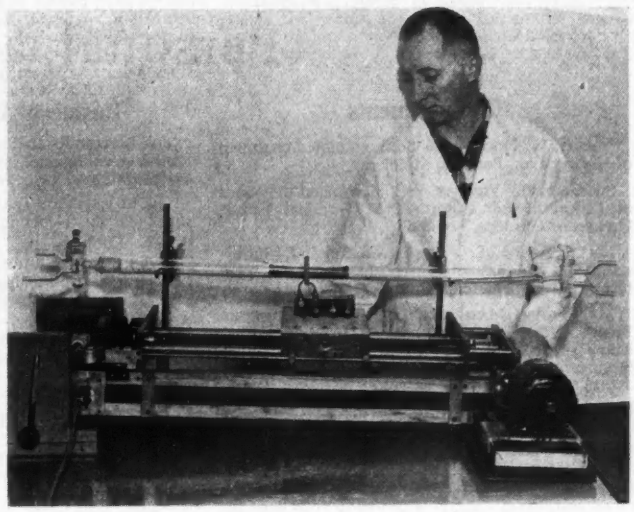
The "Pickle Barrel," a sub-critical nuclear reactor assembly, formed the main exhibit of New York University. The assembly is a laboratory tool for teaching students enrolled in the nuclear engineering courses at the New York University College of Engineering. The Atomic Energy Commission's allocation of fissionable material for the assembly was the first one made in the United States for a solely educational purpose. The assembly consists of a tank of water (in this case a 5ft deep pickle barrel, proved to be economical and technically satisfactory), 2 tons of uranium metal rods, a neutron source composed of radium-beryllium, and measuring equipment, including Geiger counters. The assembly is sub-critical because it is incapable of sustaining a full nuclear chain reaction. It does permit a production of neutrons up to 100 million per second. For each neutron from the source, eight to ten neutrons will be generated from the uranium by the quenched chain reaction.

Dr. Lyle Borst, chairman of the department of physics at the College of Engineering, applied for materials for the assembly early in 1955, and it was tested at the Brookhaven National Laboratory in the summer of 1955. Because it is sub-critical the assembly is safe at all times and requires no expensive shielding or heat removal equipment. Among the many laboratory exercises possible with the assembly are neutron measurements, experimental observations of individual components of chain reactions, foil irradiations, and the study of fission and the products of fission. In the opinion of New York University, the significance of the assembly is that at minimum expense a university can—with loan of uranium metal and a neutron source from the A.E.C.—provide engineering students with practical laboratory experience in nuclear technology. At prices current in November 1955, the uranium metal employed is valued at about 80,000 dollars. As with all fissionable materials allocated by the A.E.C., the uranium in the sub-critical assembly is held by the university on a loan basis.

Central Research Laboratories

Several interesting manipulators with ancillary equipment for "hot" laboratories were shown in actual operation at the stand of the Central Research Laboratories, Incorporated, Red Wing, Minnesota. The Model-4 master-slave manipulator is illustrated in Fig. 14. It is a general-purpose unit for use where an installation may be made over the barrier wall or through a ceiling opening of the protective enclosure. In nuclear work it has found extensive application in "canyon" installations for intermediate-level work. It is recommended where extreme shielding, restricted-space, or portability requirements are not important factors. As in all master-slave manipulators, the natural motions of the hands at the master end are reproduced identically at the slave end. These operations are accom-

Fig. 13—Joint exhibit by fourteen British manufacturers of nucleonic instruments at the exposition



Zone melting apparatus for the production of high-purity materials at the National Bureau of Standards

plished with a minimum of effort and a maximum of precision owing to careful counterbalancing, and reduction of mass, friction, and lost motion. A force of less than 2 oz is sufficient to initiate and maintain uniform motion in any horizontal direction, and less than 5 oz is necessary for vertical motion. The above factors, combined with the bilateral drive and force reflecting characteristics of the design, result in a remarkable " sense of feel " in operating the unit.

Remotely - interchangeable general - purpose tongs are standard equipment and, for repetitive or highly specialised operations, specially designed remotely-interchangeable tongs can be supplied.

The dimensions of a representative installation are shown in Fig. 14. The centre-line distance between the master and slave-end pivots and the vertical motion can be varied over a wide range. Typical dimensions are 72in for " A," 24in for " B," and 84in for " C." The unit has a handling capacity of 5 lb to 10 lb per arm.

Foreign Exhibits

Apart from Escher Wyss of Switzerland, all foreign exhibitors at the show were from the U.K. The British display, which is illustrated in Fig. 13, was organised by the Scientific Instrument Manufacturers' Association of Great Britain in collaboration with the Board of Trade and comprised products of the following British manufacturers of nucleonic instruments : Automatic Coil Winder and Electrical Equipment Company, Ltd., London S.W.1 ; Burndept, Ltd., Erith, Kent ; Cooke, Troughton and Simms, Ltd., York ; Edwards High Vacuum, Ltd., Crawley, Sussex ; Electronic Instruments, Ltd., Richmond, Surrey ; Ekco Electronics, Ltd., Southend-on-Sea, Essex ; E.M.I. Research Laboratories, Ltd., Hayes, Middlesex ; Fleming Radio (Developments), Ltd., Stevenage, Herts ; Gamma-Rays, Ltd., Smethwick, Staffs ; Labgear (Cambridge), Ltd., Cambridge ; Panax Equipment, Ltd., Mitcham, Surrey ; Sunvic Controls, Ltd., London, W.C.2 ; Townson and Mercer, Ltd., Croydon, Surrey ; M. Falk and Co., Ltd., London, S.W.1.

Zone Melting Apparatus for Production of High Purity Materials

An automatic zone melting apparatus has recently been constructed at the National Bureau of Standards, Washington, D.C. It combines versatility and dependability with unusual simplicity and ease of operation. The device is now being used in the solid state physics laboratory of the Bureau to obtain semi-conducting materials of extremely high purity. The zone melting process has been used to purify metals for several years and is now a familiar industrial and scientific tool. By this process it is possible in some cases to obtain such a high degree of purity that the remaining impurities are almost undetectable by present analytical methods. By the process it is also possible to blend in evenly a specific amount of another metal to obtain a desired alloy.

In the N.B.S. zone melter, which is illustrated at the top of the page, the solid material to be purified is placed in a fused silica or carbon boat within a " Vycor " tube. A water-cooled induction coil, concentric with the tube, is then made to pass slowly along the length of the solid material. The resultant heating effect produces a small molten zone in the bar of material. This molten zone moves along the length of the bar with the coil, causing a continuous separation of impurities at the zone boundaries. The separation occurs in such a manner that after the material has been melted a number of times, the impurities tend to concentrate at one end of the bar.

The apparatus is designed so that the operation can be carried out either in a vacuum or in an inert atmosphere. The heater coil, which is powered by a commercial 5kW unit, is mounted on a three-wheeled carriage which provides a useful travel of 18in. The wheels are mounted on ball bearings, and are guided by two $\frac{3}{4}$in diameter rods or tracks. The motion is supplied to the carriage by a $\frac{1}{2}$in diameter, 20 T.P.I. steel lead screw and a bronze nut. The nut is rubber-mounted on the centre line of the carriage. For small melts only one heating coil is used on the carriage, but provision has been made for mounting two or more coils in series if required. The coil consists of four turns of compactly wound $\frac{1}{4}$in copper tubing. It is slightly more than $\frac{1}{2}$in long and has an inner diameter of approximately $1\frac{1}{8}$in. A flow switch in the water line cuts off the heater power in case of water failure.

For the forward motion of the carriage, the lead screw is driven through a friction clutch and worm and spur reduction gears by a 1/40 h.p. shunt wound d.c. motor. The speed of the motor is nominally 1140 r.p.m., but it can be varied from about 240 r.p.m. to approximately 2000 r.p.m. by decreasing the voltage and changing the field resistance. This results in a possible variation in the rate of zone travel from $\frac{1}{4}$in per hour to 6in per hour. Adjustable stops on a simple push-pull rod, which actuates a toggle switch, limit the length of travel of the work coil. The stops may be set to allow a minimum travel of the work coil of 1in or a maximum of 18in. When the coil has reached a predetermined point, a fork on the carriage engages one of the stops and the switch is closed. This starts a 1/10 h.p. intermittent-duty motor which is directly coupled to one end of the lead screw. The rotation of the screw is reversed, and the carriage returns to its initial position at the rate of 75in per minute. This increased speed is sufficient to prevent the specimen from melting on the return portion of the cycle even though the heater current is not interrupted. When the carriage has reached the initial position, the fork engages the other of the two stops, causing the rod to open the switch and to stop the return motor.

A simple spring-loaded friction clutch is used to permit the slow speed drive motor to operate continuously, even during the rapid return of the carriage, thus eliminating the need for a more complex clutch and switching arrangement. An automatic counter registers each complete cycle. It is now being used at the N.B.S. to produce a series of inter-metallic compounds formed between the metal antimony and the metals indium, gallium, or aluminium.

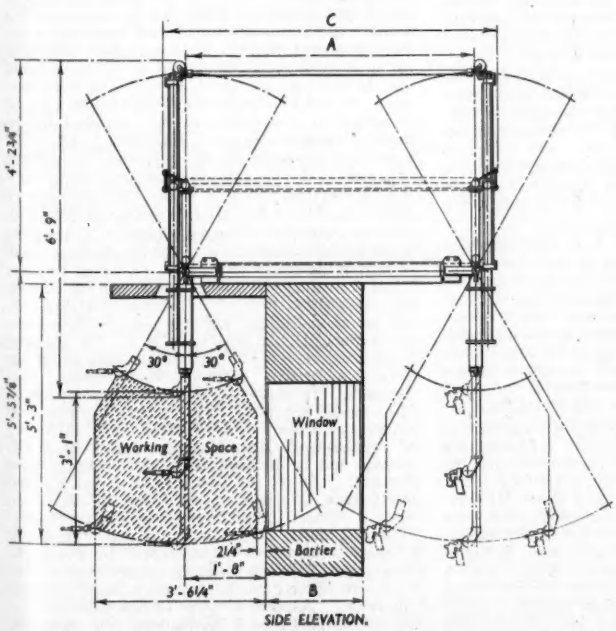


Fig. 14—General arrangement of Central Research Model-4 master-slave manipulator for " hot " laboratories

Personal and Business

Appointments

MR. H. W. HOOVER has been appointed chairman of Hoover Ltd., Perivale, Middlesex.

SIR GEOFFREY VICKERS, V.C., has joined the board of Parkinson and Cowan, Ltd., Terminal House, Grosvenor Gardens, London, S.W.1.

MARTONAIR, Ltd., Parkshot, Richmond, Surrey, states that Mr. Kenneth Friend has been appointed technical representative in the Central London area.

MR. PETER MASEFIELD, managing director of Bristol Aircraft, Ltd., has been elected an honorary fellow of the American Institute of Aeronautical Sciences.

ASSOCIATED BRITISH ENGINEERING, Ltd., states that Mr. A. R. Martin, A.M.I.Mech.E., has been appointed resident representative, in Monte Video, for Latin America.

MR. V. A. PASK, M.I.Mech.E., M.I.E.E., has joined John Brown and Co., Ltd., as consultant on power generation. Mr. Pask retired recently from the position of chief engineer of the Central Electricity Authority.

RALEIGH INDUSTRIES, Ltd., Lenton Boulevard, Nottingham, announces the appointment of Mr. J. E. Harrison as home sales director. He succeeds Mr. L. Hartwell who, for reasons of health, is retiring from executive work with the company.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION announces the appointment of Dr. J. Pearson as assistant director of research. Dr. Pearson will continue his present duties as head of the steel-making division and chemistry department.

INTERNATIONAL HARVESTER COMPANY OF GREAT BRITAIN, Ltd., 259, City Road, London, E.C.1, has announced the following appointments :—Mr. L. H. Knight, assistant manager of sales ; Mr. J. E. Busby, sales engineer, and Mr. J. F. Carroll, service manager.

THE BRITISH TRANSPORT COMMISSION has announced the appointment of Mr. V. H. Tripp, M.I.C.E., as divisional engineer, South Eastern Division, British Transport Waterways, in succession to Mr. C. A. Wilson, who is to retire on July 31st. Mr. R. H. Lake has been appointed dock manager, Regent's Canal dock.

RONALD TRIST AND CO., Ltd., Bath Road, Slough, states that Mr. R. G. Allen has been appointed chief engineer in succession to Mr. L. Bomyer. Mr. Bomyer will continue as the director responsible for technical matters and production. Mr. C. G. Scolding has been appointed sales manager and Mr. L. J. Hedges, London manager (controls).

SANDERSON BROTHERS AND NEWBOULD, Ltd., Newhall Road, Sheffield, states that Mr. J. R. A. Bull has been appointed chairman, in addition to his office as managing director. Mr. J. Harold Brown has retired from the chairmanship and from the board of the company. He has been a director for the past twenty-five years and chairman since 1938.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., Rugby, announces the appointment of Mr. D. N. Relf, A.M.I.E.E., as manager, transformer contracts, and of Mr. I. A. Ferguson, M.I.E.E., as manager of the mining department. Mr. G. W. Edgley has relinquished his position as manager of both these departments in order to take up an appointment with an associated company.

HOOVER, Ltd., Perivale, Middlesex, has announced the following appointments :—Mr. R. T. Griffiths, general sales manager (home) ; Mr. V. C. Mumford, general sales manager (export) ; Mr. G. J. Hemmings, general sales manager (Continent) ; Mr. A. W. Bunn, deputy general sales manager (home) ; Mr. P. M. J. Evans, deputy general sales manager (export), and Mr. G. S. McNamara, export sales promotion manager. Mr. R. T. Griffiths, Mr. V. C. Mumford and Mr. R. L. Webster have been appointed directors of Hoover (Washing Machines), Ltd.

THE CABLE MAKERS' ASSOCIATION announces the appointment of Mr. R. W. C. Reeves, of Johnson and Phillips, Ltd., as chairman for 1956. Mr. J. S. A. Bunting, of Edison Swan Electric Company, Ltd., has been appointed vice-chairman, and Mr. R. A. Bobb, of Crompton Parkinson, Ltd., continues as chairman of the Mains Cable Manufacturers' Association. Mr. H. B. Davies, of Enfield Cables, Ltd., has been appointed chairman of the Mains Cable Manufacturers' Association (super tension), Mr. N. B. Frost, of W. T. Henley's Telegraph Works Company, Ltd., becomes chairman of the Overseas Rubber Cable Makers' Association, and Mr. H. H. Townsend, of the Greengate and Irwell Rubber Company, Ltd., has been re-elected chairman of the Rubber and Thermoplastic Cable Manufacturers' Association.

Business Announcements

THE BRITISH ROAD FEDERATION has moved to 26, Manchester Square, London, W.1 (telephone, Welbeck 0221).

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION states that the telephone number of London Airport is now Skyport 4321.

BROOK MOTORS, Ltd., Huddersfield, states that its Leicester sales office has been moved to 1, Saxby Street, Leicester (telephone, Leicester 20648).

METALOCK (BRITAIN), Ltd., 638, Grand Buildings, Trafalgar Square, London, W.C.2, states that its telephone number has been changed to Whitehall 8902.

E. BOYDELL AND CO., Ltd., Elsinore Road, Old Trafford, Manchester, 16, states that Schwechater Maschinenbau Johann Wessely, Mohringgasse 9, Schwechat bei Wien, Austria, is its sole distributor in Austria.

GEORGE COHEN, SONS AND CO., Ltd., has acquired the entire share capital of Dunlop and Ranken, Ltd. Mr. John Dunlop, who founded the latter company in 1911, will continue to be associated with the business.

COSTAIN-JOHN BROWN, Ltd., has been appointed by the Government of India to tender advice concerning the heavy water plant which should be installed to meet the forward commitments of India's atomic energy programme.

PARKINSON AND COWAN, Ltd., states that Mr. R. Connor, A.M.I.E.E., is relinquishing his executive duties in the group. He has retired from the boards of the parent company and the subsidiaries of which he has been a director, but his services will continue to be available in an advisory capacity.

MR. K. A. SPENCER and Mr. P. W. Heselgrave have formed a consulting firm under the title Spencer and Partners. They will specialise in general corrosion prevention, practising at 19, Grosvenor Place, London, S.W.1 (telephone, Sloane 4884 and 2301). Dr. W. H. J. Vernon is associated with the practice as a consultant and adviser.

WOLF ELECTRIC TOOLS, Ltd., states that it has formed a manufacturing company in Australia entitled Wolf Electric Tools (Australia) Pty., Ltd. Mr. D. K. Nicholas, Mr. B. E. Nicholas, Mr. R. A. G. Hardy, Mr. H. Richards and Mr. G. M. Wolfe are the directors. The new company will occupy a factory which is to be built near Sydney.

Contracts

ASHMORE, BENSON, PEASE AND CO., Stockton-on-Tees, has secured a contract from the South African Iron and Steel Industrial Corporation, Ltd., for a complete blast-furnace installation at Pretoria. The furnace, which will cost about £1,000,000, is to have a hearth diameter of 25ft. and its capacity is rated at over 1000 tons of iron a day. It is intended to have the furnace ready for production early in 1958.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., has received a contract, valued at 2,000,000 dollars, from the British Columbia Electric Company, Ltd., Vancouver, for the supply of 9·9 circuit miles of single-core, 230kV, oil-filled cable. The cable will be laid in ducts and will transmit power from existing 230kV overhead lines at Kidd substation, on the north arm of the Fraser River, to distribution points in Greater Vancouver.

HUMPHREYS AND GLASGOW, Ltd., has received a contract from Imperial Chemical Industries, Ltd., for a coke breeze collecting and reclaiming installation at Billingham. Breeze from twenty-two cyclones will be received into wetting and flushing lutes, whence it will be carried by a system of ducts to settling ponds with provision for reclaiming and draining the breeze. The contract, which is valued at approximately £100,000, includes a water recirculating system, a travelling crane and all the civil engineering work.

BRUSH EXPORT, Ltd., has secured the contract to supply and install the equipment for the extensions to the Pettah power station, Colombo, and the equipment for a new power station at Jaffna. For the Pettah station the plant consists of six Mirrlees/Brush generating sets, each developing 2090kW at 428 r.p.m. and driven by a Mark KVSS.12 pressure-charged diesel engine having a continuous rating of 3096 b.h.p., and a nineteen-panel 11kV, 250MVA breaking capacity switchboard. Four Mirrlees/Brush generating sets, each developing 1045kW at 428 r.p.m., generating at 11kW and driven by a KSS6 diesel engine, are ordered for Jaffna and a fifteen-panel, 11kV, 100MVA breaking capacity switchboard.

Miscellanea

HAYLE POWER STATION.—The Central Electricity Authority has received the consent of the Minister of Fuel and Power to the extension of the Hayle power station, Cornwall, by the installation of a 20MW turbo-generator and a boiler unit having an evaporative capacity of 200,000 lb of steam an hour, making a total installed capacity of 87·8MW.

CONVENTION ON DIGITAL-COMPUTER TECHNIQUES.—In collaboration with the D.S.I.R. Committee on High-Speed Calculating Machines, the Institution of Electrical Engineers, Savoy Place, W.C.2, has arranged a Convention on Digital-Computer Techniques to be held at the Institution from April 9 to 12, 1956, followed by visits to digital-computer installations on April 13th and 14th. The convention is open to non-members of the Institution on payment of a registration fee of £1.

CARRIER-BORNE FIGHTER.—The Vickers-Supermarine "N.113" naval fighter has now flown. The Royal Navy has placed a substantial order for the aircraft, which is fitted with two Rolls-Royce "Avon" engines ; separate air intakes and jet pipes appear each side of the pointed fuselage. The wing has a "droopable" notched leading edge and provision for blowing over the high lift flaps. The dihedral tailplane is all-moving, and a long bullet extends behind its junction with the fin. The Supermarine "525," from which the "N.113" has been developed, was illustrated on January 13th last, page 44.

CANADIAN CARGO LINER "SUNRIP."—We have received from the Northern Aluminium Company, Ltd., a report upon certain aspects of the construction of the 12,825-ton deadweight Canadian cargo liner S.S. "Sunrip," built by Davie Shipbuilding, Ltd., Lauzon, Quebec, for the Sun Steamships Company. The report is concerned with the aluminium alloy superstructure and various other fittings and equipment, and includes plans of the ship, also detailed drawings and photographs, together with tables of scantlings accompanied by notes upon construction and the use of the alloys for such items as piping, ventilation, lifeboats and davits and hatch covers.

FUNCTIONS AND EDUCATION OF WELDING ENGINEERS.—A conference on "The Functions and Education of Welding Engineers," organised by the Institute of Welding, will be held at Ashorne Hill from September 16th to 18th next. Some twenty-two papers have been promised and will be discussed in four sessions. The first group will deal with the "Functions of the Welding Engineer in Industry," the second with "The Present Place of Welding in Advanced Technical Education in this Country," and the third with "The Practice of Other Countries," including the United States, France and Germany. In the last session a number of suggestions for the improvement of the facilities for the education of welding engineers will be described and discussed.

NAVAL CONSTRUCTION IN 1955.—On page 71 of our issue of January 13th, we mentioned the conversion of H.M.S. "Protector" from a fleet netlayer into a special service warship for the Antarctic. We wrote "two Admiralty three-drum type boilers and Parsons geared turbines developing 9000 s.h.p. give her a comparatively high speed of 20 knots" and that the ship was re-engined in 1945. The impression given, that the new engines were supplied by Parsons, is incorrect. They were, in fact, supplied by the British Thomson-Houston Company, Ltd. The equipment consisted of two h.p. and l.p. turbines and gearing driving port and starboard screws for a shaft horsepower rating of 9000. Our apologies are due to the British Thomson-Houston Company Ltd.

NAVAL ARCHITECTS' SPRING MEETINGS.—The spring meeting of the Institution of Naval Architects will be held in the Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, the annual general meeting will take place at 10.15 a.m. on Tuesday, March 20th, and the annual dinner will take place in the evening at Grosvenor House, Park Lane, W.1. The following is the provisional list of papers to be read during the meeting :—Tuesday morning, March 20th, "Ship Repairing," by H. A. J. Silley. Wednesday, March 21st: in the morning, "The Practical Approach to Stability of Ships," by H. E. Steel, and "A Survey of Dredges and Other Harbour Craft," by H. H. Hagan ; and, in the afternoon, "A Ship-Borne Wave Recorder," by F. J. Tucker, and "Viscous and Interference Effects Deduced from N.S.M.B. and N.P.L. 'Victory' Model Tests," by Dr. G. Hughes. Thursday, March 22nd : in the morning, "The Brittle Fracture Strength of Welded Steel," by Dr. A. A. Wells, and "Contra-Rotating Propellers," by Dr. J. D. van Manen and Dipl.-Ing. A. Sentic ; in the afternoon, "Aspects of Ship Vibration Induced by Twin Propellers," by J. W. Ramsay, and, at a joint meeting with the Institute of Marine Engineers, "Corrosion of Merchant Ship Hulls," by H. J. Adams and Dr. J. C. Hudson.

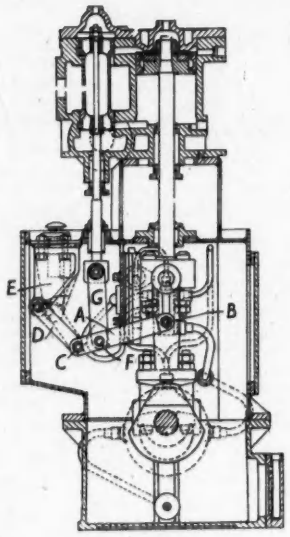
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgement is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgement, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

STEAM ENGINES

743,363. July 17, 1953.—RECIPROCATING STEAM ENGINES, Drysdale and Co., Ltd., and John Young, both of the company's address at Bon-Accord Works, Yoker, Glasgow.

The invention relates to improvements in reciprocating steam engines. The steam engine shown in the drawing has a valve gear which is actuated exclusively from the connecting rod and a crankshaft which may be turned end-for-end in its bearings so that the driving end may be available as required at either end without interference with the valve gear. The driving end of the crankshaft may be provided with a flange or other coupling and the other end of the crankshaft may be arranged to operate an oil pump. The valve gear includes a twin rock



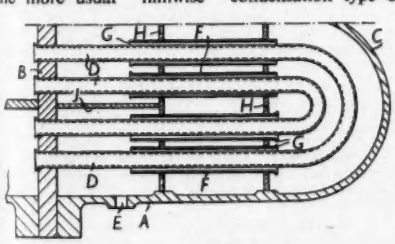
No. 743,363

lever *A* pivotally connected at one end *B* to a point along the length of the connecting rod. At the other end the lever is pivotally connected at *C* to one end of a twin swing-arm *D*, of which the other end is connected to a supporting bracket *E*. The rock lever carries a cross pin *F* to which is pivotally connected one end of a link *G*. The other end of this link is connected to a valve spindle which transmits movement to a piston or other steam-distributing valve of the engine. The engine is non-reversible and there is no provision for variation of the characteristics of the indicator diagram by simple adjustment of a working part.—*January* 11, 1956.

HEAT EXCHANGERS

741,988. January 22, 1952.—HEAT EXCHANGE APPARATUS, Arthur Hoare, Cyril Raymond Hoare and Stanley Neville Hoare, all of Railway View, Portsmouth, Hampshire.

The invention relates to heat exchange apparatus of the kind which is particularly adapted to effect "dropwise" condensation in contradistinction to the more usual "filmwise" condensation type of



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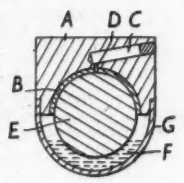
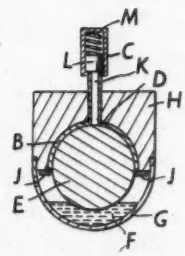
apparatus. Referring to the drawing, the apparatus comprises a housing *A* which is closed at one end by a plate *B* and at the other end by a domed portion *C*. Fitted within the housing are any desired number of U-shape conduits *D* providing inlet and outlet tubes for carrying feed water to be preheated, the ends of these conduits being supported by the end plate *B*. The housing is formed with an inlet (not shown) for steam under pressure, and also with an outlet *E* for condensate. Each conduit is enclosed for a part of its length in a tubular member *F* and the inlet ends *G* of these tubular members are tapered as shown to effect rapid flow of the steam through the tubular members in intimate contact with the conduits. Owing to the restriction of area of the annular space between each conduit and a tubular member *F*, caused by the flaring of the inlet end *G*, a rapid or turbulent flow is obtained, so ensuring good heat transference. The water passing through the conduits *D* may flow in the same direction as the flow of steam so that the coolest water is first influenced by the steam, or it may flow in the opposite direction. The tubular members *F* are carried and supported by partitions or baffles *H* and a dividing wall *J* is provided in the space between the end plate *B* and the baffle. This wall separates the inlet limbs of the conduits from their outlet limbs. Thus, the steam must pass from the inlet through the tubular members *F* around the inlet limbs of the conduits into a compartment at the domed end *C* of the housing and then through the tubular members *F* around the outlet limbs of the conduits and then to the outlet for condensate.—*December* 14, 1955.

BEARINGS AND SUPPORTS

740,590. September 7, 1953.—PLAIN BEARINGS, The Glacier Metal Company, Ltd., 368, Ealing Road, Alperton, Wembley, Middlesex. (*Inventor: Phil Prince Love.*)

The invention is concerned with an improved construction of plain bearing or assembly which is of particular use on railway vehicles, especially carriages of electric railways. The invention has for its object to provide an improved construction of plain bearing which will be capable of rapid re-establishment of full fluid lubrication of the bearing after a limited period, e.g. thirty seconds, from the moment of stopping of the vehicle, such period being sufficient to cover the usual duration of a stop at a station and the initial period of acceleration on re-starting until oil pressure again builds up. As will be seen from the drawing, the plain journal bearing comprises an upper half bearing *A* having a semi-cylindrical cavity in its underside fitted with a suitable bearing liner *B*. This body incorporates an air-tight reservoir *C* communicating with the bearing surface through a substantially central bleed hole or holes *D*. A journal *E* may, at its lower part, dip into an oil bath *F* contained in a casing *G*. In the modification illustrated in the lower view the plain bearing liner *B* of any suitable kind is secured by clamping elements *J* or otherwise fitted into a housing *H* and an air-tight reservoir *C* remote from the bearing liner *B* communicates with a bleed hole *D* in the liner through a conduit *K*. In either arrangement the reservoir *C* may be of the accumulator type embodying a piston *L* movable against a preloaded spring *M*. Other design modifications are also described in the specification.—*November* 16, 1955.



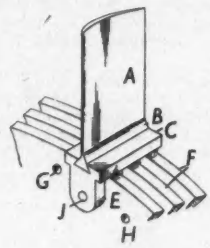


No. 740,590

COMPRESSORS AND TURBINES

740,757. October 27, 1952.—BLADES FOR COMPRESSORS AND TURBINES, Power Jets (Research) and Development), Ltd., 25, Green Street, London, W.1. (*Inventors: Sydney William Henry Perry, Sidney James Hildred Burt and Frederick Desmond Crick.*)

The invention relates to blades, and particularly rotor blades for compressors, turbines and like machines. Its object is to provide a construction which will be cheap and light, and can be readily mass produced. The invention is not necessarily intended to be suitable for steam and gas turbines operating at high temperatures. Referring to the drawing, the blade comprises a blade part *A* which is a length of solid material cut from a rolled strip of the required cross-section. The root end of this strip is formed with a chordwise-extending enlargement *B* which is of constant and substantially dovetail cross-section. The blade further comprises a root block *C* which is formed in its surface with an undercut groove comforming in cross-section to the enlargement *B* on the end of the blade. This enlargement is slid into the groove from the end and secured in position by brazing or welding. The underside of the root block *C* is formed with a number of prongs *E*. As shown, the curved under-surface of the root block rests on the periphery of a rotor made up of a number of spaced rotor discs *F* with which the prongs interlock. The prongs and the rotor discs are formed with registering holes *G* and *H*, into which a pin *J* is inserted to secure the blade.



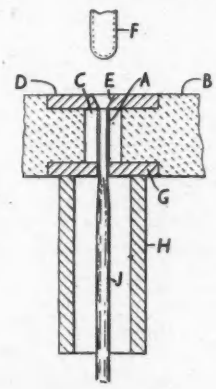
No. 740,757

The root blocks of adjacent blades abut with each other to make up a complete cylindrical surface around the rotor. The rotor construction is described in the co-pending patent specification No. 724,281. Modified designs of root blocks are also described in the specification.—*November* 16, 1955.

METALLURGY

743,348. April 27, 1953.—THE CASTING OF METALS, Low Moor Alloy Steelworks, Ltd., Low Moor, Bradford. (*Inventor: Jack Sydney Gerber.*)

In the casting of steel and other metals having a high casting temperature it is often impossible to obtain a clean stream of metal, owing to skulling and freezing in the nozzle or owing to erosion of the nozzle. These difficulties are overcome in the invention by apparatus including a vessel for holding molten metal having an outlet nozzle in the form of a tube of refractory material. In the drawing, the nozzle is shown as formed by a refractory tube *A* of any required bore, having a wall thickness of, say, $^1/_{10}$in, and a length about equal to the thickness of the ladle bottom *B*. The tube which may be of mullite, or other material of suitable refractoriness, extends through an aperture in the ladle bottom which is of considerably larger cross section so that over substantially its whole length the tube is surrounded by an annular air space *C* which may measure, say, $\frac{1}{4}$in in radial



No. 743,348

width. At its upper end the space *C* is closed by a horizontal plate or brick *D* of refractory material formed with an aperture in which the upper end of the tube *A* is secured. The wall *E* of this aperture is chamfered downwardly, so that it serves as a guide or centring device for a stopper *F* when it is lowered to close the nozzle. The refractory brick *D* may be replaced by a flange formed integrally upon the upper end of the nozzle tube. The stopper *F* used in conjunction with this nozzle may be of the normal solid construction, but is preferably formed as shown, as a thin-walled refractory tube with a closed lower end. The lower end of the annular air space *C* surrounding the nozzle tube is closed by a second horizontal plate or brick *G* of refractory material. The nozzle tube fits closely in the aperture of this plate and is held correctly centred. The air space *C* surrounding the nozzle tube may be heated by a high frequency coil accommodated in the space. If desired, the tube *A* may be surrounded by suitable heat insulating material instead of an air space as shown. A tubular protective sheath *H* projects from the underside of the ladle, so as to surround the stream of metal *J* leaving the lower end of the nozzle tube and prevent free access of air. This sheath has a bore substantially greater than that of the nozzle tube and the stream of metal passes freely through without coming into contact with it. The specification also shows the invention applied to a tundish for use in pouring metal into a continuous casting mould and a side-pouring vessel.—*January* 11, 1956.

Launches and Trial Trips

CANOPUS, minesweeper; built by the Chantiers et Ateliers, Augustin Normand for the French Navy; length overall 46·30m, breadth 8·52m, draught 2·17m, displacement 393 tons, speed 15 knots; two S.E.M.T. diesel engines driving one shaft through 1250/375 reduction gearing, 1800 h.p. Launch, December 31st.

JEANNE SCHIAFFINO, cargo ship; built by the Anciens Chantiers Dubigeon for the Société Algerienne de Navigation (Schiaffino); length overall 261ft 2in., length between perpendiculars 238ft 6½in, breadth moulded 38ft 5in. depth 21ft 10in, draught 15ft 1½in, deadweight 1450 tons, trial speed 12·2 knots; one supercharged M.A.N. diesel engine, mark G8V 40-60-400. Trial, December.

MEUDON, cargo ship; built by the Chantiers Reunio Loire-Normandie for the Compagnie d'Orbigny; length overall 438ft 2in., length between perpendiculars 413ft 6in, breadth moulded 56ft 1½in, depth 34ft, draught loaded 23ft, deadweight 7700 tons, gross tonnage 4700, service speed 13·5 knots; two complete decks, seven watertight bulkheads, six holds, one 15-ton and eleven 5-ton derricks; electric deck machinery, one 150kW turbo-driven generator, three 100kW diesel-driven generators; one set of geared turbines, 3500 s.h.p., steam supplied at 525 lb per square inch and 750 deg. Fah. by two Penhoet boilers. Trial, December.

MOONIE, cargo ship; built by the Chantiers de Provence for the Messageries Maritimes; length overall 488ft 4½in, length between perpendiculars 467ft 8in, breadth moulded 61ft 8in, depth to shelter deck 38ft 11in, draught loaded 25ft 7in, deadweight 8300 tons, displacement 14,079 tons, speed 16 knots; six passengers; three complete decks and seven watertight bulkheads, five holds, one 60-ton, one 30-ton, four 10-ton and ten 5-ton derricks; electric deck machinery, three 250kW diesel-driven generators and one 30kW emergency generator; one single-acting, two-stroke Burmeister and Wain engine of 8300 h.p. at 115 r.p.m., built by the Forges et Acieries du Creusot (Schneider). Trial, December.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Feb. 10th.—STOKE AND CREWE BRANCH: North Stafford Hotel, Stoke, "Power System Protection," F. E. Wellman, 8 p.m.

Mon., Feb. 13th.—CENTRAL LONDON BRANCH: St. Ermins Hotel, Caxton Street, S.W.1, "Underground Railways Electrical Practice," R. H. Tintalf, 7 p.m.——N.W. LONDON BRANCH: Century Hotel, Forty Avenue, Wembley Park, "Space Heating by Electricity," R. D. Jackson, 8.15 p.m.

Tues., Feb. 14th.—BOURNEMOUTH BRANCH: Grand Hotel, Firvale Road, Bournemouth, "Installation and Operation of a Television Station," E. P. B. Metcalfe, 8 p.m.——LUTON BRANCH: Midland Hotel, Williamson Street, Luton, "Automatic Temperature Control," S. O. Grant, 8 p.m.

Thurs., Feb. 16th.—KENT BRANCH: Rose and Crown Hotel, Tonbridge, "Safety in Electrical Installations," 8 p.m.——WATFORD BRANCH: Clarendon Hotel, Station Road, Watford, Herts, "Electricity in the Marine Industry," J. Bushby, 8.15 p.m.

Sat., Feb. 18th.—OXFORD, READING AND DISTRICTS BRANCH: Y.M.C.A., 10, George Street, Oxford, "Radio Frequency Heating," B. Kellett, 6.30 p.m.

BATTERSEA POLYTECHNIC

Tues., Feb. 14th.—Battersea Polytechnic, London, S.W.11, "Mechanical Testing of Metals," A. W. Layton, 7 p.m.

BRITISH BOTTLERS' INSTITUTE

Mon., Feb. 13th.—Wheatsheaf Hotel, High Street, Manchester, "Heat Utilisation in Our Industry," John Fox, 6.30 p.m.

DIESEL ENGINEERS AND USERS ASSOCIATION

Thurs., Feb. 16th.—GENERAL MEETING: Caxton Hall, Westminster, London, S.W.1, "Cast Iron in Diesel Engines," J. G. Pearce, 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Feb. 13th.—LEEDS CENTRE: Yorkshire Electricity Board, Ferensway, Hull, "Cold Cathode Lighting," G. Robinson and A. E. Fothergill, 7 p.m.——SHEFFIELD CENTRE: The University, Western Bank, Sheffield, "Photometric and Other Tests for Street Lighting," W. A. Varney, 6.30 p.m.

Tues., Feb. 14th.—SESSIONAL MEETING: Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, "Lighting at London Airport," J. G. Holmes, 6 p.m.

Wed., Feb. 15th.—N. LANCASHIRE GROUP: N.W. Electricity Board, 19, Friargate, Preston, "Recent Work on Discomfort Glare," R. G. Hopkinson and P. Petherbridge, 7.15 p.m.——TEES-SIDE GROUP: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Prescribing for Seeing," M. L. Berson, 6.30 p.m.

Thurs., Feb. 16th.—MANCHESTER CENTRE: N.W. Electricity Board, Town Hall Extension, Manchester, "Recent Work on Discomfort Glare," R. G. Hopkinson and P. Petherbridge, 6 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Feb. 13th.—DUNDEE BRANCH: Mathers Hotel, Dundee, "Lifting Gear," J. W. Steele, 7.30 p.m.

Tues., Feb. 14th.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "Application of Maintenance of Centrifugal Pumps," G. O. Stevenson and A. J. Clements, 7.15 p.m.

Wed., Feb. 15th.—KENT BRANCH: Bull Hotel, Rochester; "Diesel Engine Development." R. W. Stuart Mitchell, 7 p.m.

Thurs., Feb. 16th.—BLACKBURN BRANCH: Golden Lion Hotel, Blackburn, "Current Lubricants and their Significance to Plant Engineers," J. Chisholm, 7.30 p.m.——MERSEYSIDE AND N. WALES BRANCH: Royal Institution, Colquitt Street, Liverpool, "Steam Turbines in Plant Engineering," W. J. Kearton, 7.15 p.m.

Fri., Feb. 17th.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, Films, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

To-day, Feb. 10th.—TEES-SIDE BRANCH: Teesdale Hall, Head, Wrightson and Co., Ltd., Thornaby-on-Tees, "Foundry Problems and Principles," G. J. Rogers, 7.30 p.m.

Sat., Feb. 11th.—NEWCASTLE BRANCH: Neville Hall, Westgate Road, Newcastle upon Tyne, "Cupola Practice," W. Y. Buchanan, 6 p.m.——SCOTTISH BRANCH: Royal Technical College, Glasgow, "Scrap Investigation," J. McGrandle, 3 p.m.

Sat., Feb. 18th.—BRISTOL AND W. OF ENGLAND BRANCH: Grand Hotel, Bristol, "Light Alloy Practice," C. J. Williams, 3 p.m.——E. MIDLANDS BRANCH: College of Technology and Commerce, Leicester, "The Design and Operation of Two Water-cooled Cupolas," D. W. Berridge and J. R. Hawley, 6 p.m.

INSTITUTE OF FUEL

To-day, Feb. 10th.—SCOTTISH SECTION: North British Hotel, Edinburgh, "Smokeless-Fuel Production," A. Vaughan Cowell, 7 p.m.

Wed., Feb. 15th.—Institution of Civil Engineers, Great George Street, London, S.W.1, "The Oil-from-Coal Project of the South African Government," P. E. Rousseau, 5.30 p.m.——N.W. SECTION: Grosvenor Hotel, Chester, "Combustion of Liquid Fuels," G. J. Gollin, 7.30 p.m.——YORKSHIRE SECTION: Royal Victoria Hotel, Sheffield, "Solid-fuel-burning Gas Turbines," J. D. Thorn, 2.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Feb. 13th.—STUDENT LECTURE: 85, Minories, London, E.C.3, "Boilers," W. C. Carter, 6.30 p.m.

Tues., Feb. 14th.—85, Minories, London, E.C.3, "Some Considerations of Wear in Marine Gearing," W. H. Darlington; "Some Teething Troubles in Post-War Reduction Gears," S. Archer, 5.30 p.m.

Thurs., Feb. 16th.—N.E. COAST SECTION: Stephenson Building, King's College, Claremont Road, Newcastle upon Tyne, Annual General Meeting: Symposium of Papers, "Advanced Machinery Installations Designed for the Maximum Saving in Weight and Space," T. W. F. Brown, P. Jackson and E. H. Smith, 6.15 p.m.

INSTITUTE OF NAVIGATION

Wed., Feb. 15th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The Abridged Nautical Almanac," D. H. Sadler, "Navigating Without Instruments," P. Beeham, "The Earth Satellite Project," J. G. Porter, 5 p.m.

INSTITUTE OF PETROLEUM

Wed., Feb. 15th.—STANLOW BRANCH: Grosvenor Hotel, Chester, "Combustion of Liquid Fuels," G. J. Gollin, 7.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Feb. 13th.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Development of the Lightweight Oil Engine," H. L. Parrish, 7.30 p.m.——E. REGION CENTRE: Council Chamber, Houldsworth Hall, 90, Deansgate, Manchester, "Welding," H. Gibson, 7.30 p.m.

Tues., Feb. 14th.—MIDLANDS CENTRE: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "The Economics of Fleet Operation," A. S. Gilman, 7.30 p.m.

Thurs., Feb. 16th.—LONDON CENTRE: Royal Society of Arts, John Adam Street, London, W.C.2, "The Training of Drivers for Commercial and Public Service Vehicles," B. K. Young, 6.30 p.m.——YORKSHIRE CENTRE: Great Northern Hotel, Wellington Street, Leeds, 1, "Road and Rig Testing of Prototype Road Transport Vehicles and Their Components," J. H. Alden, 7.30 p.m.

INSTITUTE OF WELDING

Tues., Feb. 14th.—E. MIDLANDS BRANCH: Victoria Station Hotel, Nottingham, "The Use of Oxygen in Industry," E. Ryalls, 7.15 p.m.——LIVERPOOL BRANCH: College of Technology, Byrom Street, Liverpool, "Commercial Radiography," R. Gould, 7.15 p.m.——N. LONDON (SLOUGH SECTION): Community Centre, Farnham Road, Slough, "The Part of Resistance Welding in Automation," R. W. Ayers, 7.30 p.m.——S. WALES BRANCH: S. Wales Institute of Engineers, Park Place, Cardiff, "Welded Structure of New South Stand at Cardiff Arms Parks," J. M. Burke, 6.30 p.m.

Wed., Feb. 15th.—W. OF SCOTLAND BRANCH: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Welding at the Atomic Plants," L. Rotherham, 6.30 p.m.——WOLVERHAMPTON BRANCH: Victoria Hotel, Wolverhampton, "Gas Welding," F. Clark, 7.30 p.m.

Thurs., Feb. 16th.—SOUTHAMPTON BRANCH: Technical College, St. Mary's, Southampton, "Metallurgy," A. Prince, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Feb. 14th.—Great George Street, Westminster, London, S.W.1, "The Design and Construction of Aden Oil Harbour," J. E. G. Palmer and Harold Scrutton, 5.30 p.m.

Wed., Feb. 15th.—N.W. ASSOCIATION: 9, The Temple, 24, Dale Street, Liverpool, "Diving Equipment—Its Development and Uses in Civil Engineering Works," I. E. Fraser, 6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Feb. 13th.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "Power Supplies to Electrical Laboratories," opened by P. F. Soper, 6 p.m.

Tues., Feb. 14th.—MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, "An On-Off Servomechanism with Predicted Change-over," J. F. Coales and A. R. M. Noton, 5.30 p.m.——LONDON GRADUATES AND STUDENTS SECTION: Public Library, Chelmsford, "Television Outside Broadcast Control Units," F. H. Steele, 7 p.m.

Wed., Feb. 15th.—FARADAY LECTURE: Central Hall, Westminster, S.W.1, "Coal Mining Electrically," B. L. Metcalf, 6 p.m.

Thurs., Feb. 16th.—UTILIZATION SECTION: Savoy Place, London, W.C.2, "The Theory and Characteristics of the 3 : 1 Pole-Changing Induction Motor" and "Applications of the 3 : 1 Pole-Changing Motor," T. H. Barton, O. I. Butler and H. Sterling; "The Development of a New 3 : 1 Pole-Changing Motor," G. H. Rawcliffe and B. V. Jayawant, 5.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Feb. 14th.—39, Elmbank Crescent, Glasgow, "Modern Metal Cutting," G. V. Stabler, 6.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

To-day, Feb. 10th.—MANCHESTER AND DISTRICT BRANCH: Engineers' Club, Albert Square, Manchester, "Process Control in Industry," J. E. Fielden, 6.30 p.m.

Tues., Feb. 14th.—S.W. BRANCH: Castle Hotel, Taunton, "Forced Circulation for Central Heating Systems for Small Houses," S. A. Burke, 6.30 p.m.

Wed., Feb. 15th.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "Some Aspects of Intermittent Heating," E. Harrison, 6 p.m.——LIVERPOOL AND DISTRICT BRANCH: College of Building, Clarence Street, Liverpool, "Low Pressure Steam Installations," T. H. F. Holman, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 10th.—GENERAL MEETING, APPLIED MECHANICS GROUP: 1, Birdcage Walk, London, S.W.1, "Oil Flow and Film Extent in Complete Journal Bearings," J. A. Cole and C. J. Hughes, "An Experimental Investigation into Stepped Thrust Bearings," R. C. R. Johnston and C. F. Kettleborough, 5.30 p.m.——SCOTTISH BRANCH: Robert Gordon's College, Aberdeen, "Marine Reduction Gearing," A. W. Davis, 7.30 p.m.——SOUTHERN BRANCH: Municipal College, Bournemouth, "Control Valves for Direct Hydraulic Presses," F. H. Towler, 7 p.m.

Tues., Feb. 14th.—AUTOMOBILE DIVISION GENERAL MEETING: 1, Birdcage Walk, London, S.W.1, "The M.I.R.A. Proving Ground," A. Fogg, 5.30 p.m.——S. WALES BRANCH: Blackworth Hotel, Swansea, "Instrumentation for the Process Industries," B. W. Balls, 6 p.m.

Wed., Feb. 15th.—SOUTHERN BRANCH: College of Technology, Anglesea Road Extension, Portsmouth, "Gas Turbines for Marine Uses," Lt.-Cmdr. Stewart, 7 p.m.

Thurs., Feb. 16th.—EDUCATION GROUP: 1, Birdcage Walk, London, S.W.1, Discussion, "Technical Authorship and Illustration," 6.45 p.m.——MIDLAND BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Promotion of Fluid Lubrication in Wire Drawing," D. G. Christopherson, 7.30 p.m.

Fri., Feb. 17th.—GENERAL MEETING, STEAM GROUP: 1, Birdcage Walk, London, S.W.1, "Testing of Boilers and Turbo-Alternators in Power Stations," H. S. Horsman, 5.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Wed., Feb. 15th.—INFORMAL MEETING: Conference Room, 4th Floor, Waterloo Bridge House, London, S.E.1, "Work Unit Assessment and Employment," C. E. E. Clinch, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Feb. 10th.—EASTERN COUNTIES SECTION: Diocesan Hall, Tower Street, Ipswich, "Drop Forging," G. Kemp, 7.30 p.m.——W. WALES SECTION: Central Library, Alexandra Road, Swansea, "Automation for Production," F. Garner, 7.30 p.m.

Mon., Feb. 13th.—S. WESTERN SECTION: Cornwall Technical College, Treverson, Pool, Redruth, "The Right Material in the Right Place," Hugh Bartle, 7 p.m.——SHEFFIELD SECTION: Grand Hotel, Sheffield, "Copying Devices," J. Lund, 6.30 p.m.

Tues., Feb. 14th.—DONCASTER SECTION: Danum Hotel, Doncaster, "Industrial Applications of Atomic Energy," H. Lysons, 7 p.m.——OXFORD SECTION: Town Hall, Oxford, "The Application of Hydraulic Mechanisms to Automatic Processes," I. McNeill, 7.15 p.m.

Wed., Feb. 15th.—BIRMINGHAM SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Recent Developments in High Production Foundries," J. D. Berry, 7 p.m.——EDINBURGH SECTION: North British Station Hotel, Edinburgh, "Voith Schneider Propeller with particular reference to its Manufacture," A. Betts Brown, 7.30 p.m.——S. ESSEX SECTION: Ilford Club, 21A, Balfour Road, Ilford, "Machine Tool Development," N. Stubbs, 7.30 p.m.——WESTERN SECTION: University Engineering Laboratories, University Walk, Bristol, 8, "Automatic Inspection—The Anatomy of Conscious Machines," J. A. Sargrove, 7.15 p.m.

Thurs., Feb. 16th.—N. IRELAND SECTION: Kensington Hotel, College Square East, Belfast, "Metrology from the Designer's Point of View," H. G. Conway, 7.30 p.m.——GLASGOW SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Electro Spark Machining," G. Fefer, 7.30 p.m.——READING SECTION: Great Western Hotel, Reading, "Welding Up to Date," F. Powner, 7.30 p.m.——SOUTHERN SECTION: Polygon Hotel, Southampton, "Tube Work and Manipulation," L. C. Hackett, 7.15 p.m.——LONDON SECTION: Royal Empire Society, Northumberland Avenue, W.C.2, "Milling versus Broaching," A. R. Hambridge, 7 p.m.

INSTITUTION OF PUBLIC HEALTH ENGINEERS

Thurs., Feb. 16th.—SESSIONAL MEETING: Caxton Hall, Westminster, London, S.W.1, "Modern Applications of Ion Exchange," B. A. Sard, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 10th.—ORDINARY MEETING: Pepys House, 14, Rochester Row, London, S.W.1, "A Production Control System Incorporating an Electronic Computer," W. J. Kease, 7 p.m.

Mon., Feb. 13th.—N.W. SECTION: Engineers' Club, Albert Square, Manchester, "Variable Speed Gears and Some Industrial Applications," M. Carter and J. Fieldhouse, 7 p.m.——SHEFFIELD AND DISTRICT SECTION: Livesey Clegg House, Sheffield, Film Evening, 7.30 p.m.

Fri., Feb. 17th.—INFORMAL MEETING: Pepys House, 14, Rochester Row, London, S.W.1, "The Engineer Goes Sailing," N. J. Bowyer Lowe, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Feb. 17th.—Engineers' Club, Albert Square, Manchester, "Diesels," C. J. Hind, 6.45 p.m.

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Thurs., Feb. 16th.—Mining and Technical College, Wigan, "The Use of Methane in Dual Fuel Internal Combustion Engines at Point of Ayr Colliery," G. Nicholls, 3.15 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Feb. 10th.—Mining Institute, Newcastle upon Tyne, "Bearings for Marine Geared Turbines," A. D. Newman, 6.15 p.m.

OLD CENTRALIANS

Tues., Feb. 14th.—Mapleton Restaurant, 39, Coventry Street, London, W.1, "Heavy Structural Vibrations," J. H. A. Crocket, 12.45 p.m.

REINFORCED CONCRETE ASSOCIATION

Wed., Feb. 15th.—11, Upper Belgrave Street, London, S.W.1, "Recent Research on the Vibration of Concrete," J. M. Plowman, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Feb. 16th.—FIRST STRINGFELLOW MEMORIAL LECTURE: Congregational Church, Princes Street, Yeovil, "Stringfellow—His Life and Work," A. M. Ballantyne, 7 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., Feb. 14th.—Geological Society, Burlington House, Piccadilly, London, W.1, "Manufacture of Phosphorus," F. B. Shepherd, 5.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., Feb. 17th.—Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Electric Drives for Hot Rolling Mills," H. S. Brown and J. C. Easton, 6.45 p.m.